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ANALYSIS OF WATER QUALITY DATA FOR THE DON RIVER - SUPPORTING DOCUMENT #5: STRATEGY FOR IMPROVEMENT OF DON RIVER WATER QUALITY

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ANALYSIS OF WATER QUALITY DATA FOR THE DON RIVER SUPPORTING DOCUMENT # 5: STRATEGY FOR IMPROVEMENT OF DON RIVER WATER QUALITY

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and Paul Theil Associates Ltd.

Report prepared for:
Steering Committee
Toronto Area Watershed Management Study

AUGUST 1991

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ABSTRACT

A summary of the water quality characteristics of the Don River is given in this document. It is based largely on the time series analysis of monitoring station data for the Don River made by Dr. Byron Bodo of the Ontario Ministry of the Environment. His assistance in preparation of this document is gratefully acknowledged. Data for organic parameters are also summarized from TAWMS studies conducted on the Don River.

FOREWARD

Study Background

In 1981, the Ontario Ministry of the Environment (MOE) began a study of water quality in the Don River, Humber River and Mimico Creek to provide baseline data to guide future studies. The following year, the Toronto Area Watershed Management Strategy Study (TAWMS) was initiated as a comprehensive and co-operative multi-agency undertaking towards the attainment of water quality improvements.

The TAWMS study objectives are:

- To better define water quality conditions with the study area;
- To analyse the cause and effect relationships for problem constituents and areas; and
- To develop cost-effective measures for controlling pollutant loadings to the study area's receiving waters based on watershed needs and users.

Although wholly funded by MOE, TAWMS receives extensive co-operation and support from the Metropolitan Toronto and Region Conservation Authority (MTRCA), Metropolitan Toronto and area municipalities.

The TAWMS study is managed by a Steering Committee which includes representatives of the following:

Ontario Ministry of the Environment
Ontario Ministry of Natural Resources
Metropolitan Toronto & Region Conservation Authority
Environment Canada
Metropolitan Toronto
Borough of East York
City of Etobicoke
City of North York
City of Scarborough
City of Toronto
City of York
Regional Municipality of York
Regional Municipality of Peel
Town of Richmond Hill
Town of Vaughan
Town of Markham

A detailed study of the Humber River was carried out during the period 1982 to 1985. In 1986, the TAWMS Steering Committee released a Management Plan for the Humber River. Recommendations which were outlined in this plan are presently being implemented.

The TAWMS Don River Water Quality Improvement Study was commissioned as an external contract to Paul Theil Associates Limited and Beak Consultants Limited in the spring of 1988. The study's mandate was to summarize water quality problems, relate these problems to sources and to provide a range of improvement actions leading to various levels of control for water quality improvements. Options investigated for water quality improvement range from no further degradation to the full restoration of water quality in the Don River. The findings were presented as alternatives or staged management strategies which will lead to several milestones or levels of water quality improvement.

The improvement strategy incorporates findings from previous investigations of low flow and storm event conditions, snow melt, the status of biological communities and general water quality conditions within the Don River.

Public consultation on a number of strategies for water quality improvement for the Don River, combined with inputs from a range of municipalities and agencies will provide valuable direction for drafting the final Don River Management Plan. Improvement strategies outlined in this report for the Don River and other rivers which drain into the waterfront will be considered in context of the Metro Toronto Remedial Action Plan (RAP), a provincial-federal initiative for protecting water quality in Toronto's waterfront.

Implementation considerations and costs are important components in this option selection/consultant process, since they identify in simple terms what it will take to achieve a range of improvements and benefits or designated uses of the Don River. This consultation process will also recognize the will of municipalities, government agencies, developers and the public to support selected undertakings to protect and enhance water quality in the Don River.

The time span in which water quality improvements are to be derived and the ultimate costs will depend upon the levels of protection and the phasing of controls selected on the basis of public feedback and agency and municipality endorsement. It is recognized that effective improvement actions in the Don River watershed will also require creative solutions and new approaches by the municipalities and government agencies.

In addition to the remedial measures proposed in the strategy, a number of immediate actions are presently underway to address water quality problems by means of regular municipal and conservation authority works and maintenance programs, or through Ministry of the Environment programs such as the Waterfront Water Quality Improvement Program which funds physical work on the watercourses, waterfront or sewers yielding immediate benefits.

This document is Supporting Document 5 for the study. The complete set of study reports are as follows.

1. STRATEGY FOR IMPROVEMENT OF DON RIVER WATER QUALITY: SUMMARY REPORT

2. SUPPORTING DOCUMENT NO. 1: QUANTITATIVE METHODOLOGY FOR ESTIMATING RESPONSE OF DON RIVER TO WATER QUALITY CONTROL

3. SUPPORTING DOCUMENT NO. 2: FRAMEWORK FOR EVALUATING RESPONSE OF AQUATIC TOXICITY AND FISH HABITAT TO WATER QUALITY CONTROL IN THE DON RIVER

4. SUPPORTING DOCUMENT NO. 3 METHODOLOGY FOR EVALUATING IMPACTS OF SPILL REMEDIATION AND OTHER REMEDIAL OPTIONS UPON DON RIVER WATER QUALITY

5. SUPPORTING DOCUMENT NO. 4: PROBLEM DEFINITION: PRESENT STATE OF WATER QUALITY IN THE DON RIVER

6. SUPPORTING DOCUMENT NO. 5: ANALYSIS OF WATER QUALITY DATA FOR THE DON RIVER

Availability of Reports

Copies of the Supporting Documents and the Summary Report for the Strategy for Improvement of Don River Water Quality are available through the:

Public Information Centre
Water Resources Branch
135 St. Clair Avenue W.
Suite 100
Toronto, Ontario
M4V 1P5
(416) 323-4321

DISCLAIMER

THIS STUDY WAS UNDERTAKEN THROUGH A CONTRACT FROM THE METROPOLITAN TORONTO AND REGION CONSERVATION AUTHORITY (MTRCA) AND THE ONTARIO MINISTRY OF THE ENVIRONMENT (OMOE). THE STUDY FINDINGS HAVE BEEN REVIEWED BY THE MTRCA AND OMOE BUT DO NOT NECESSARILY REPRESENT THE POLICY OR POSITION OF EITHER OF THESE AGENCIES.

THIS REPORT HAS BEEN REVIEWED BY THE STEERING COMMITTEE AND APPROVED FOR PUBLICATION. APPROVAL DOES NOT NECESSARILY SIGNIFY THAT THE CONTENTS REFLECT THE POSITION AND/OR POLICIES OF INDIVIDUAL AGENCIES.

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2.0 WATER QUALITY CHARACTERISTICS OF THE DON RIVER

An extensive analysis of monitoring data for the Don River from Ontario's Provincial Water Quality Monitoring Network (PWQMN) has been made by Bodo (1987). Bodo advocates use of the following techniques:

1. to alert authorities to water quality degradation; so that appropriate corrective action may be initiated; and

2. to evaluate the performance of pollution abatement measures usually undertaken at great public and private expense.

Bodo (1987) developed these techniques because standard parametric statistical trend tests cannot be applied to data which have the following characteristics:

1. uneven spacing in time;
2. high background variability (low signal-to-noise ratio);
3. non-normality (skew);
4. numerous outliers;
5. autocorrelation;
6. seasonal periodicity;
7. non-monotonic trends.

Non-parametric tests avoid most of these factors, but rely on the assumption that trend is always proceeding in the same direction, either increasing or decreasing. Such non-parametric tests cannot be applied to the monitoring data because non-monotonic trends occur.

In this section, the result of application of these techniques are summarized here for a variety of parameters. The main data is summarized in Tables 2.1 to 2.6; representative plots are also reproduced. The data base from which the analysis is derived, are as follows:

TABLE 2.1: DON RIVER @ LAKESHORE BLVD. (1974-1986) (MOE STATION #001)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Temperature	Annual Range 90: 4-24 50: 2-24 10: 0-19	None	Yes	NA
DO	Range 2-14 mg/L Summer Seasonal Range 90%: 8 mg/L 50%: 6 mg/L 10%: 4.5 mg/L	small increase; apparent equipment problem in 1968-72 makes trend analysis results doubtful	Yes	10-20% PWQO violation in 1973-81 5% PWQO violations in 1981-1986
BOD	Mean 1984-86: 3.7 mg/L	decrease	None, perhaps a small effect	Summer exceedance of 10 mg/L is approximately 20%
pH	Max. 8.5 Q50 7.7 Min. 7.0	-	-	None
Alkalinity	Summer Q75 80 mg/L Q50 180 mg/L Q25 160 mg/L	None	Yes - dip in spring	-
Suspended Solids	Q75 80 mg/L Q50 15 mg/L Q25 5 mg/L	None	-	-
Turbidity	Q75 20 FU Q50 10 FU Q25 5 FU		None	--
Chloride	Range of 12 month average for 83-86 120-250 mg/L	Mean increased from 140 (in 60's) to 190 mg/L by late 70's.	Yes; annual mean amplitude from 500 (winter) to 200 (summer) mg/L	-
Conductivity	12 month avg. for 83-86 800-1600 umhos/cm	Similar to, but weaker trend than chloride	Yes; annual mean amplitude from 1000 to 2000 umhos/cm @ 25°C.	-
Dissolved Solids	12 month avg. for 83-86: 600-900 mg/L	Small decrease from 725-745 mg/L in 1960's to mean levels of 695 in 1970-1980's	Yes; annual mean amplitude from 1000 (winter) to 600 (summer) mg/L	-

TABLE 2.1: (cont'd.) DON RIVER @ LAKESHORE BLVD. (1974-1986) (MOE STATION #001)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Total Coliforms	Median: 10^4 to 10^5/100 ml	Decrease 1968 to 1972; stable increase 1976 to 1980; decrease 1983 to 1984	-	
Fecal Coliform	Median: 10^2 to 10^3/100 ml	Similar to TC	-	
Total Phosphorus	1964 to 1968: 1.6 mg/L 1984 to 1986: .19 mg/L	Sharp decline in 1972; slow decrease 1972 to 1984	-	See Table 2.8
Ammonia	1968: 5 mg/L; 1986: 1 mg/L	Gradual decline from 1966 to 1986	-	38% for unionized ammonia
TKN	1966: 6 mg/L; 1986: 2 mg/L	Gradual decline 1966 to 1986	-	No PWQO value
Nitrate	1966: 0.5 mg/L; 1986: 1.5 mg/L	Gradual increase 1966 to 1986	-	Not reported

TABLE 2.2: DON RIVER @ TODMORDEN (1972-1986) (MOE STATION #007)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Temperature	not given by Bodo similar to Don @ Lakeshore	None	Yes	NA
DO	Median Range: 8-12 mg/L	None	Yes	None; all values higher than Don River at Lakeshore
BOD	Annual mean 3-4 mg/L	Decrease	None	-
pH	Max. 8.8 Q50 7.5 Min. 6.2	-	-	12%
Alkalinity	Spring Q25 230 mg/L Q50 210 mg/L Q75 130 mg/L	-	-	
Suspended Solids	Q75 300 mg/L Q50 16 mg/L Q25 5 mg/L	-	-	-
Turbidity	Q75 160 FU Q50 10 FU Q25 5 FU	-	-	-
Chloride	Range of 12 month average for 83-86 120-200 mg/L	Slight decline; marginally less than Lakeshore station	-	-
Conductivity	12 month average for 83-86 800-2000 umhos/cm @ 25°C	Slight decrease	Annual mean amplitude from 1000 to 1600 mg/L	-
Dissolved Solids	12 month average for 83-86: 600-700 mg/L	Slight decrease	-	-
Total Coliforms	10^2 to 10^5 median values for 1973 to 1984	Similar to Don River at Todmorden	None	
Fecal Coliform	10 to $10^{2.5}$ median values for 1973 to 1984	Similar to TC	None; however, violation statistics indicate that violation frequencies exceed 80% for the following periods: Feb. 9 - April 13 (snowmelt/spring runoff) June 18 - Aug. 19 (summer low flows) Nov. 2 - Dec. 1 (Nov. rains/moderate flows)	greater than 80% for 3 indicated periods for data from period of 1979-1986

TABLE 2.2: (cont'd.) DON RIVER @ TODMORDEN (1972-1986) (MOE STATION #007)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Total Phosphorus	1980-1982: 0.4 mg/L 1984: .20 mg/L	Decrease from 1972 to 1979; increase in 1980 plateau 1980-1984; decrease in 1984	-	See Table 2.8
Ammonia	1973: 2.5 mg/L 1986: 0.5 mg/L	Constant decrease	-	17% for unionized (NH_3) ammonia
TKN	1973: 5 mg/L; 1986: 1.5 mg/L	Constant decrease	-	No PWQO value
Nitrate	1986: 1.5 mg/L	Small increase over time	-	No reported

TABLE 2.3: GERMAN MILLS CREEK @ RICHMOND HILL (1965-1986) (MOE STATION #005)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Temperature	-	-	-	-
DO	-	Small increase from 83 to 87; possible bias due to sampling	-	-
BOD	log BOD for 1984-1986 is -0.2 to 0.6	Reduction due to elimination of STP	-	-
pH	Max. 9.4 Q50 7.8 Min. 5.2	-	-	6%
Alkalinity	not given	-	-	-
Suspended Solids	Q75 130 mg/L Q50 15 mg/L Q25 6 mg/L	-	-	-
Turbidity	Q75 60 FU Q50 15 FU Q25 5 FU	-	-	-
Chloride	-	-	-	-
Conductivity	Mean trend 1983-1986 900 to 800 umhos/cm @ 25°C	Increase from 1966-78, drop of 400 umhos/cm in 1979	-	-
Dissolved Solids	-	-	-	-
Total Coliforms	Median $10^{1.2}$ to $10^{4.5}$ per 100 ml	see text	-	80% to 100% violation
Fecal Coliform	-	see text	-	10% (1973) to 100% violation 1980-1984
Total Phosphorus	1970-76: 4 mg/L 1982-86: 0.06 mg/L	decrease over whole period drop in 1976 and 1982	-	see text

TABLE 2.3: (cont'd.) GERMAN MILLS CREEK @ RICHMOND HILL (1965-1986) (MOE STATION #005)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Ammonia	1965: 10 mg/L; 1986: 0.03 mg/L	Decline whole period; drop in 1981; constant post-1981	-	No violations for unionized NH_3
TKN	1965: 15 mg/L; 1986: 0.2 mg/L	Same as ammonia	-	None reported
Nitrate	1975: 6 mg/L; 1986: 0.4 mg/L	Increase 1965 to 1981: drop in 1981; constant post-1981	-	None reported

TABLE 2.4: EAST DON RIVER @ BAYVIEW AND STEELES (1964-86) (MOE STATION #003)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Temperature	-			
DO	Annual variation 7-13 mg/L	None	-	no violations since 1981 for PWQO for cold water biota
BOD	log BOD: 0.1 to 0.3 for 1984-86	Reduction due to elimination of STP	-	-
pH	Max. 8.7 Q50 7.7 Min. 6.4	-	-	4%
Alkalinity	not given	-	-	-
Suspended Solids	Q75 160 mg/L Q50 20 mg/L Q25 3 mg/L	-	-	-
Turbidity	Q75 160 FU Q50 10 FU Q25 4 FU	-	-	-
Chloride	-	-	-	-
Conductivity	Mean trend 1983-86 = 700 umhos/cm @ 25°C	Increase from1964 to 1978 drop of 200 umhos/cm in 1979	-	-
Dissolved Solids	-	-	-	-
Total Coliforms	Median $10^{3.6}$ (1972) to $10^{4.8}$ (1980) per 100 ml	see text	-	15% violation in 1972 to 100% violation in 1980-1984 of PWQO's.
Fecal Coliform				75% (1972) to 100% (1980-1986) violation of PWQO's
Total Phosphorus	1976-81: 0.4 mg/L 1984-86: 0.08 mg/L	increase 1966 to 72; constant 1972 to 82; drop in 1982, constant 1983-86		see text

TABLE 2.4: (cont'd.) EAST DON RIVER @ BAYVIEW AND STEELES (1964-86) (MOE STATION #003)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Ammonia	1976: 0.8 mg/L; 1986: 0.03 mg/L	Increase 1966 to 1976; drop in 1981 constant 1983 to 1986	-	None for unionized ammonia
TKN	1980: 2 mg/L; 1986: 0.5 mg/L	Increase 1966 to 1981; drop in 1981; small decline 1983 to 1986	-	Not reported
Nitrate	1981: 3 mg/L; 1986: 0.6 mg/L	Increase 1966 to 1981; drop 1981; small decline 1982 to 1986	-	Not reported

TABLE 2.5: WEST DON RIVER @ SHEPPARD AVE. (1966-1980) (MOE STATION #002)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Temperature	-	-	-	-
DO	Annual range: 7-13 mg/L	None	-	No violations of PWQO's for cold water biota objectives since mid 1970's.
BOD	log BOD for 1978-1980 is 0.1 to 1	Decrease from 1976 to 1980	-	-
pH	Max. 8.8 Q50 7.6 Min. 6.4	-	-	4%
Alkalinity	not given	-	-	-
Suspended Solids	Q75 60 mg/L Q50 15 mg/L Q25 5 mg/L	-	-	-
Turbidity	Q75 50 FU Q50 15 FU Q25 4 FU	-	-	-
Chloride	-	-	-	-
Conductivity	Mean 1983-86 is approximately 800 umhos/cm @ 25°C	No trend for 1966-78; drop of 100 umhos/cm in 1979	-	-
Dissolved Solids	-	-	-	-
Total Coliforms	$10^{3.5}$ to $10^{4.2}$ per 100 ml	see text	-	80% violations (1968, 1976) to 95% violation (1972 and 1980)
Fecal Coliform	-	see text	-	70% to 90% violations using a 3-year window
Total Phosphorus	1975: 0.6 mg/L 1986: 0.08 mg/L	Increase from 1966 to 75; drop in 1976; decline to 1986	-	see text
Ammonia	1976: 0.8 mg/L; 1986: .16 mg/L	Increase 1965 to 1977; drop in 1977 decrease 1977 to 1986	-	No violation for unionized ammonia
TKN	1977: 2.5 mg/L; 1978: 0.8 mg/L	Abbreviated data series 1964-1980 increase 1964 to 1977; drop 1977	-	None reported
Nitrate	1974: 0.1 mg/L; 1979: 0.04 mg/L	Increase 1964 to 1973; decline to 1980; no data post 1980	-	None reported

TABLE 2.6: WEST DON RIVER @ HIGHWAY 7 (1964-1986) (MOE STATION #004)

Parameter	Values of Parameter	Trend	Seasonality	Frequency of Violations
Temperature	-	-	-	
DO	Annual range: 7-13 mg/L (value of 15 mg/l are disregarded)	None; increase suggested by data from 1973 to 1979 is discounted	-	No violations of PWQO for cold water biota objectives since mid 1970's
BOD	log BOD for 1984-1986 is -0.2 to 0.8	Decrease from 1972 to 1979	-	-
pH	Max. 8.4 Q50 7.8 Min. 6.5	-	-	None
Alkalinity	not given	-	-	-
Suspended Solids	not given	-	-	-
Turbidity	Q75 130 FU Q50 15 FU Q25 5 FU	-	-	-
Chloride	-	-	-	-
Conductivity	Mean 1983-86 is approximately 800 umhos/cm @ 25°C	Small Increase from 1966 to 1978; drop of 300 umhos/cm in 1978	-	-
Dissolved Solids	-	-	-	-
Total Coliforms	-	see text	-	40% violations (1976) to 90% violations (1972 and 1980)
Fecal Coliform	-	see text	-	80% to 70% violations using a 3-year window
Total Phosphorus	1975: 3 mg/L 1986: 0.1 mg/L	Increase from 1966 to 1975; drop in 1975; decrease to 1986	-	see text
Ammonia	1976: 3 mg/L; 1986: 0.03 mg/L	Increase 1966 to 1977; drop in 1977 slow decline 1977 to 1986	-	No violation for unionized ammonia
TKN	1976: 8 mg/L; 1986: 0.6 mg/L	Same as for ammonia	-	None reported
Nitrate	1974: 0.7 mg/L; 1981: 3 mg/L	Increase 1966 to 1981; no data after 1981	-	None reported

Station ID		Station Description
Lower Don	001	Don River @ Lakeshore
	007	Don River @ Todmorden
East Don	003	East Don River @ Bayview & Steeles
	005	German Mills Creek below Richmond Hill STP
West Don	002	West Don River @ Sheppard
	004	West Don River @ Highway 7

Station locations are indicated in Figure 2.1.

2.1 Temperature

Temperature follows the typical seasonal profile expected (Figure 2.2a) with no significant long-term trend apparent (Figure 2.2b).

2.2 Dissolved Oxygen

Dissolved oxygen follows a seasonal profile as expected from seasonal temperature considerations. The "dip" in dissolved oxygen values for the 1968-1972 period is regarded by Bodo as an artifact and is hence disregarded in this analysis. There is no long term DO trend apparent from the annual data (Figure 2.3 to 2.8) except for possibly the West Don River at Highway 7 where the Richmond Hill Treatment plant was removed in 1979. Because the concentration of DO in 1985-1986 was greater than 9 mg/L the "apparent trend" is probably an artifact.

2.3 BOD

A typical plot of BOD data is given in Figure 2.9. There is a decrease apparent in all BOD data over the 1974-1980 period. The decrease results from an improvement in STP operation (in the case of the lower Don River) and/or removal of STP discharges (e.g., Figure 2.10) to the system (e.g., Richmond Hill Plant removal).

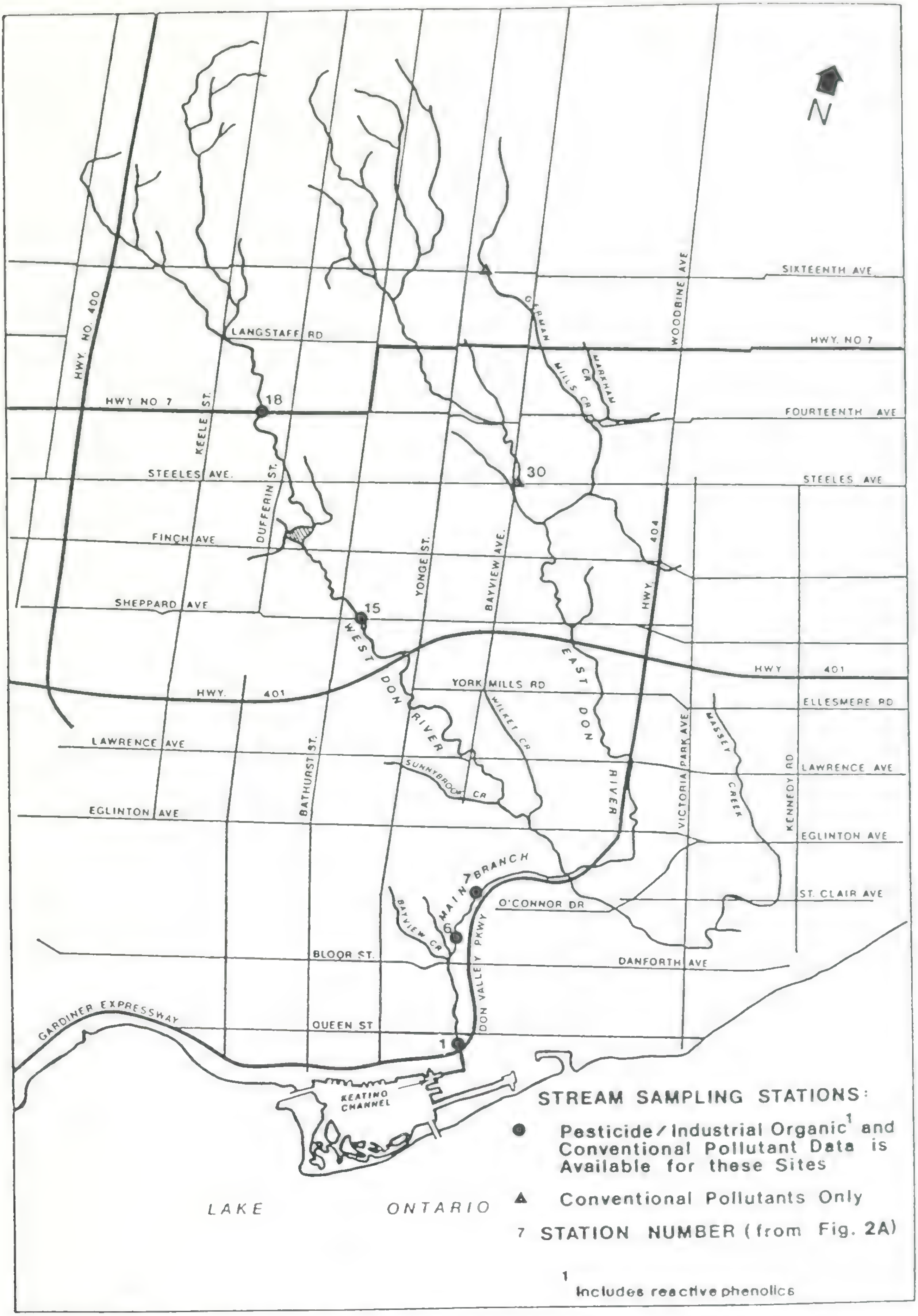
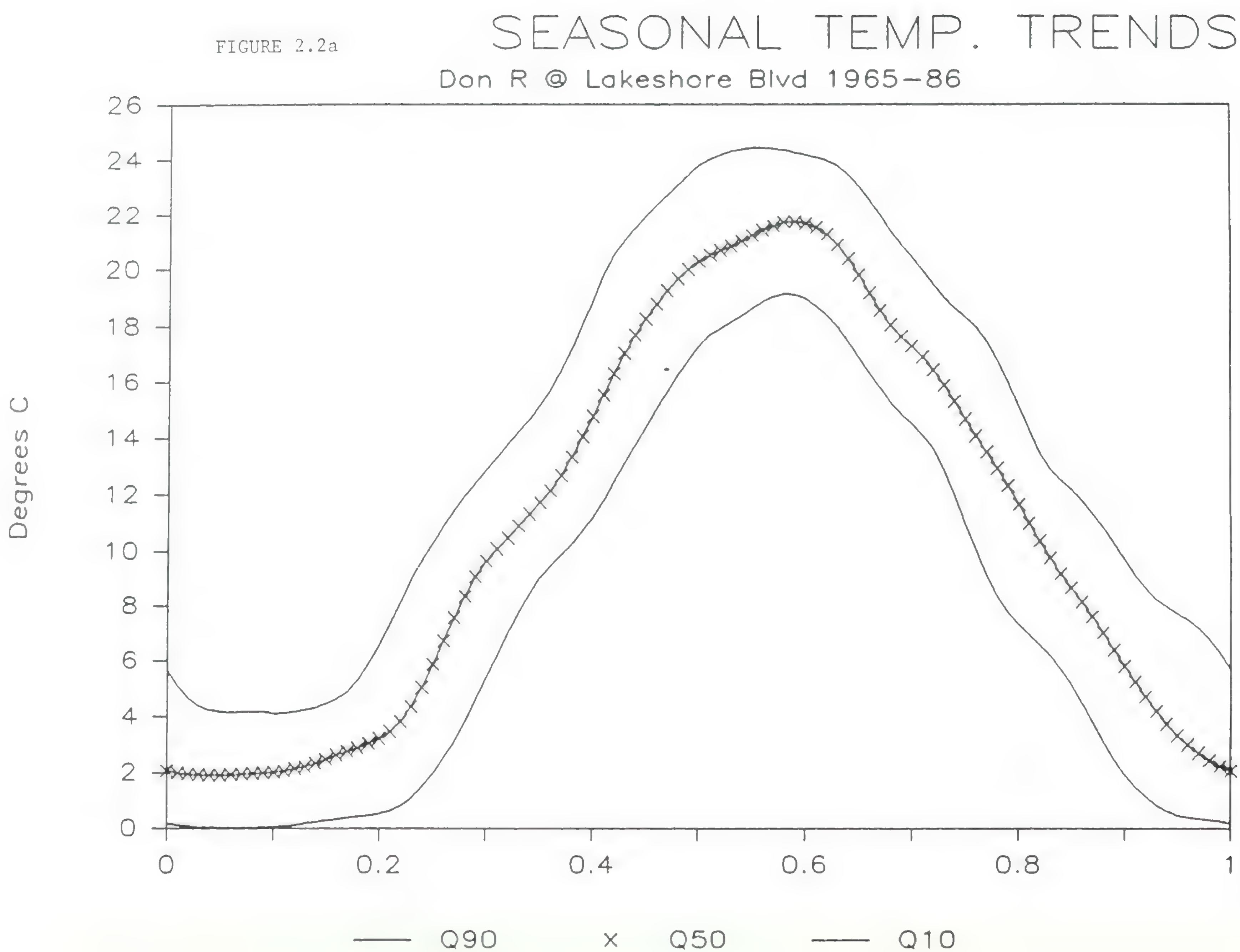


FIGURE 2.1: PROVINCIAL WATER QUALITY MONITORING NETWORK (PWQMN) STATIONS, DON RIVER AND

FIGURE 2.2a



SEASONAL TEMP. TRENDS
Don R @ Lakeshore Blvd 1965-86
Degrees C
26
24
22
20
18
16
14
12
10
8
6
4
2
0
0.2
0.4
0.6
0.8
1
Q90
x Q50
Q10

FIGURE 2.2b

TEMPERATURE TRENDS

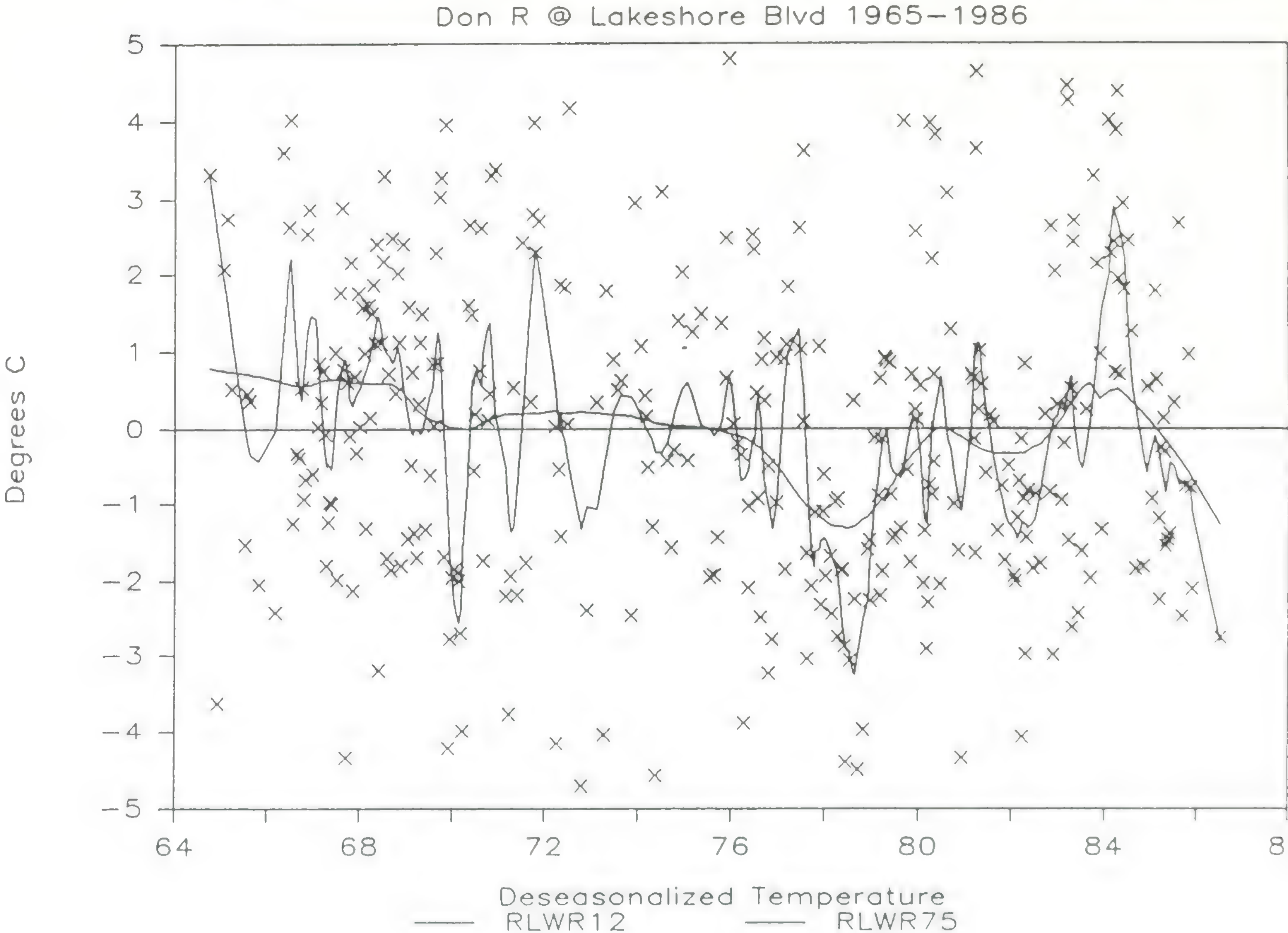
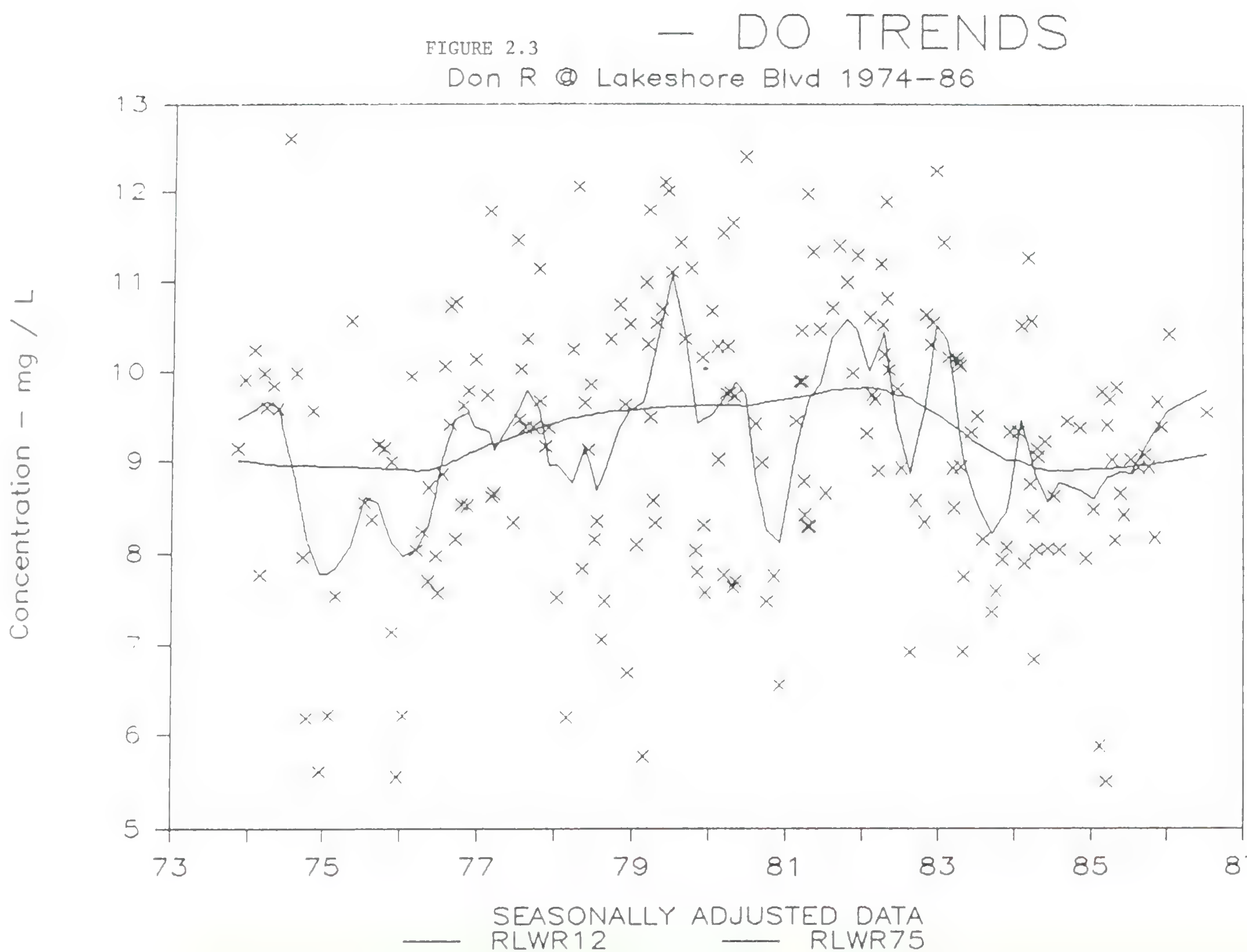


FIGURE 2.3



— DO TRENDS
Don R @ Lakeshore Blvd 1974–86
Concentration – mg / L
13
12
11
10
9
8
7
6
5
73
75
77
79
81
83
85
87
SEASONALLY ADJUSTED DATA
RLWR12
RLWR75

FIGURE 2.4

— DO TRENDS

Don R @ Todmorden 1974–86

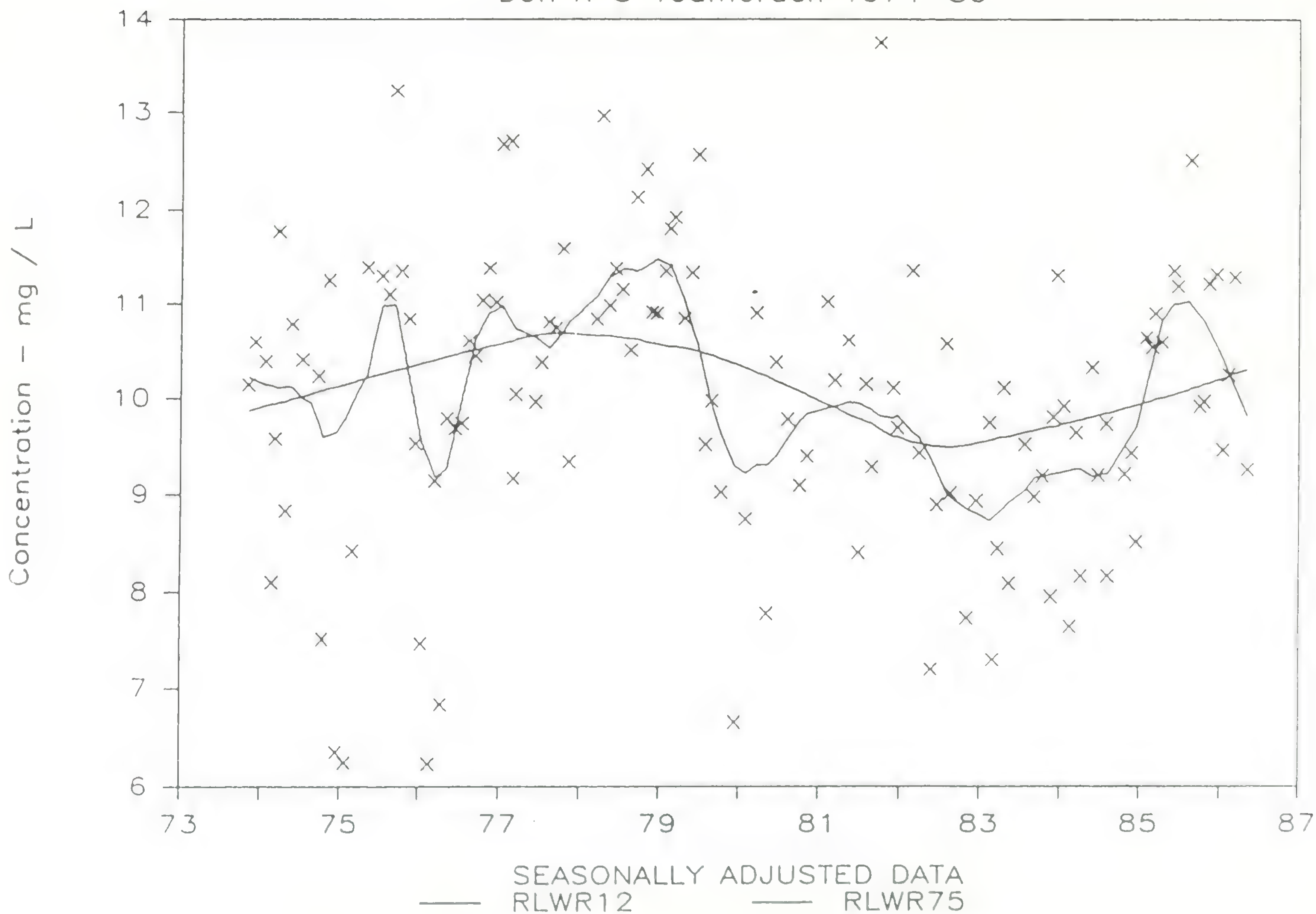
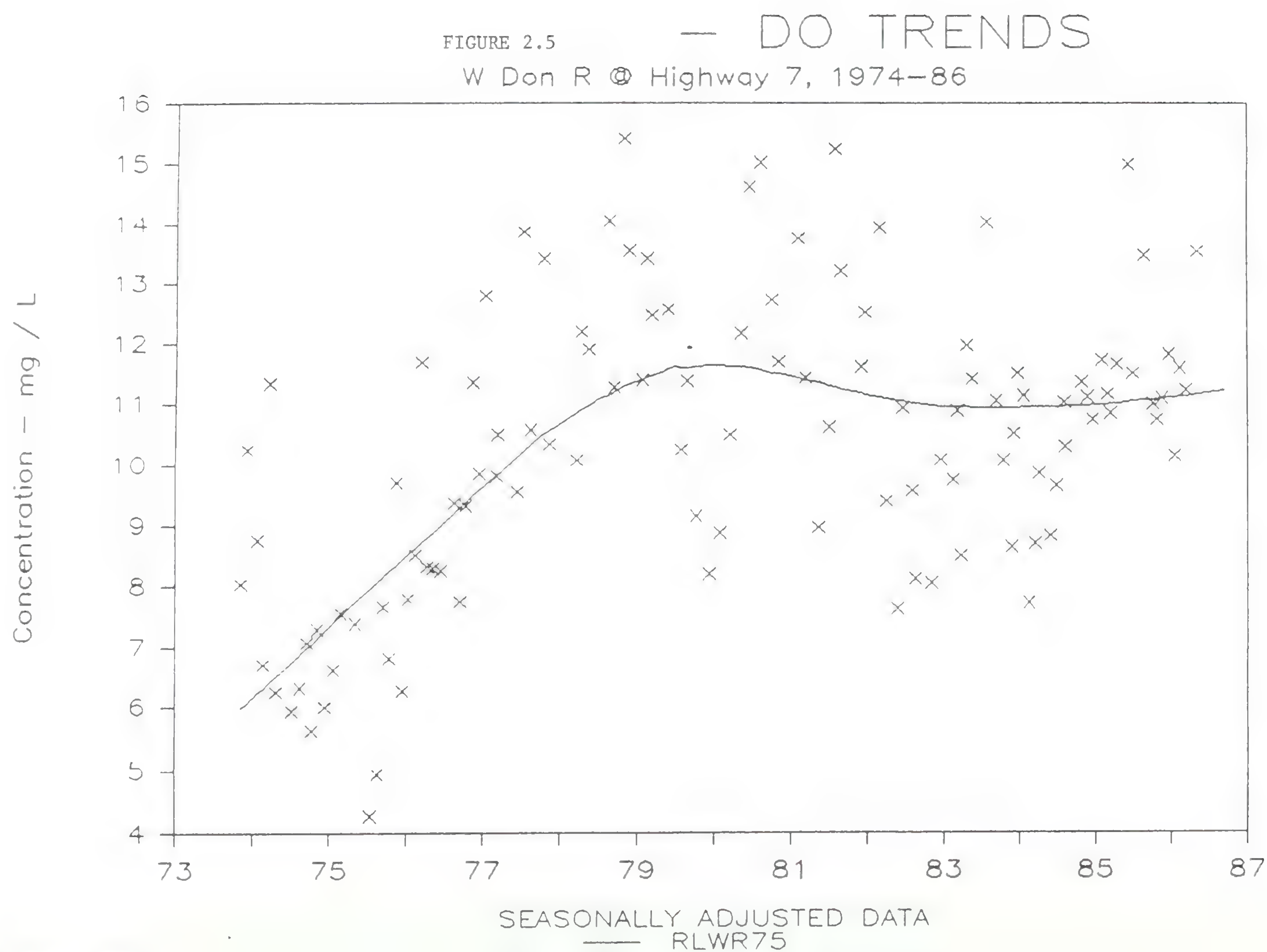
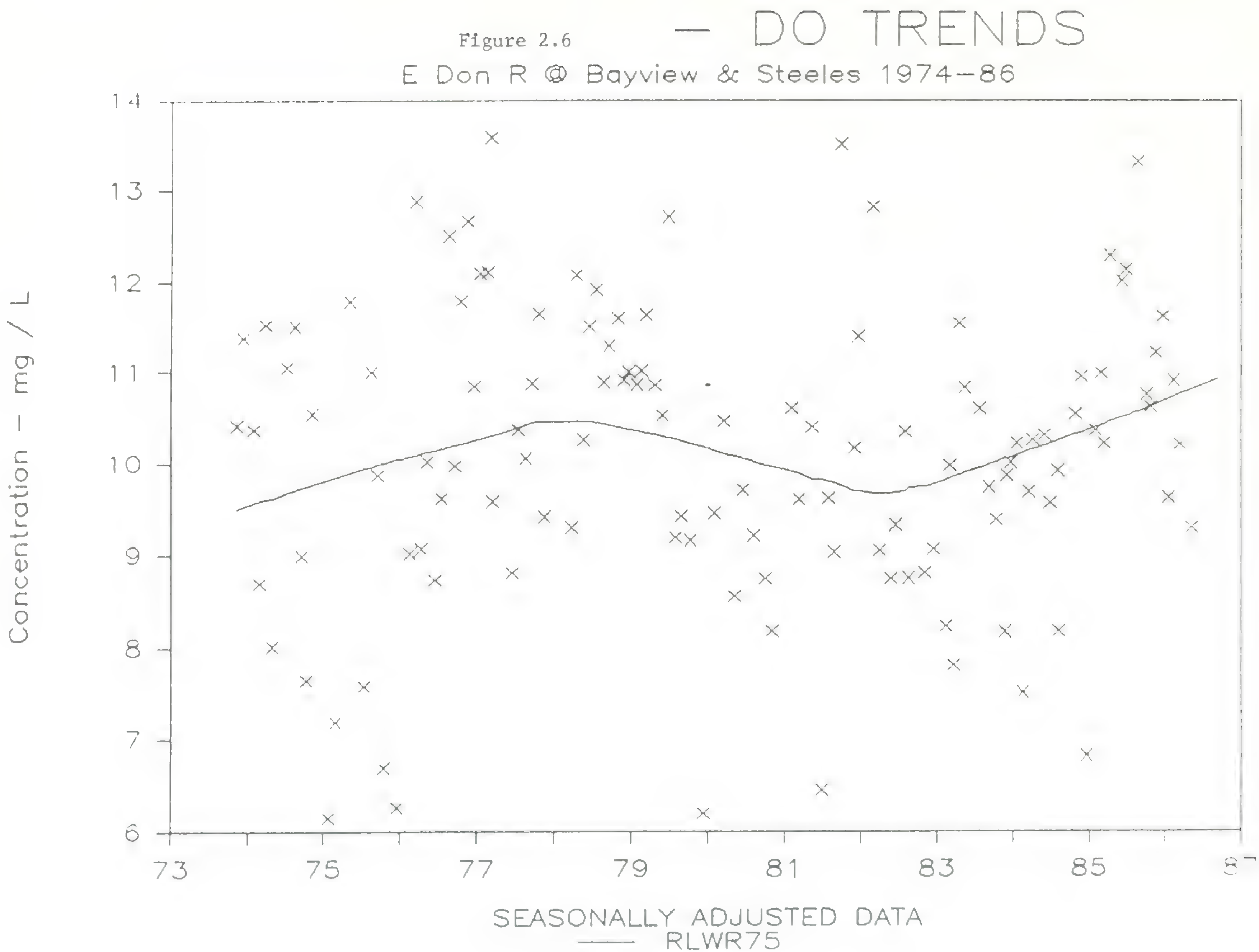


FIGURE 2.5



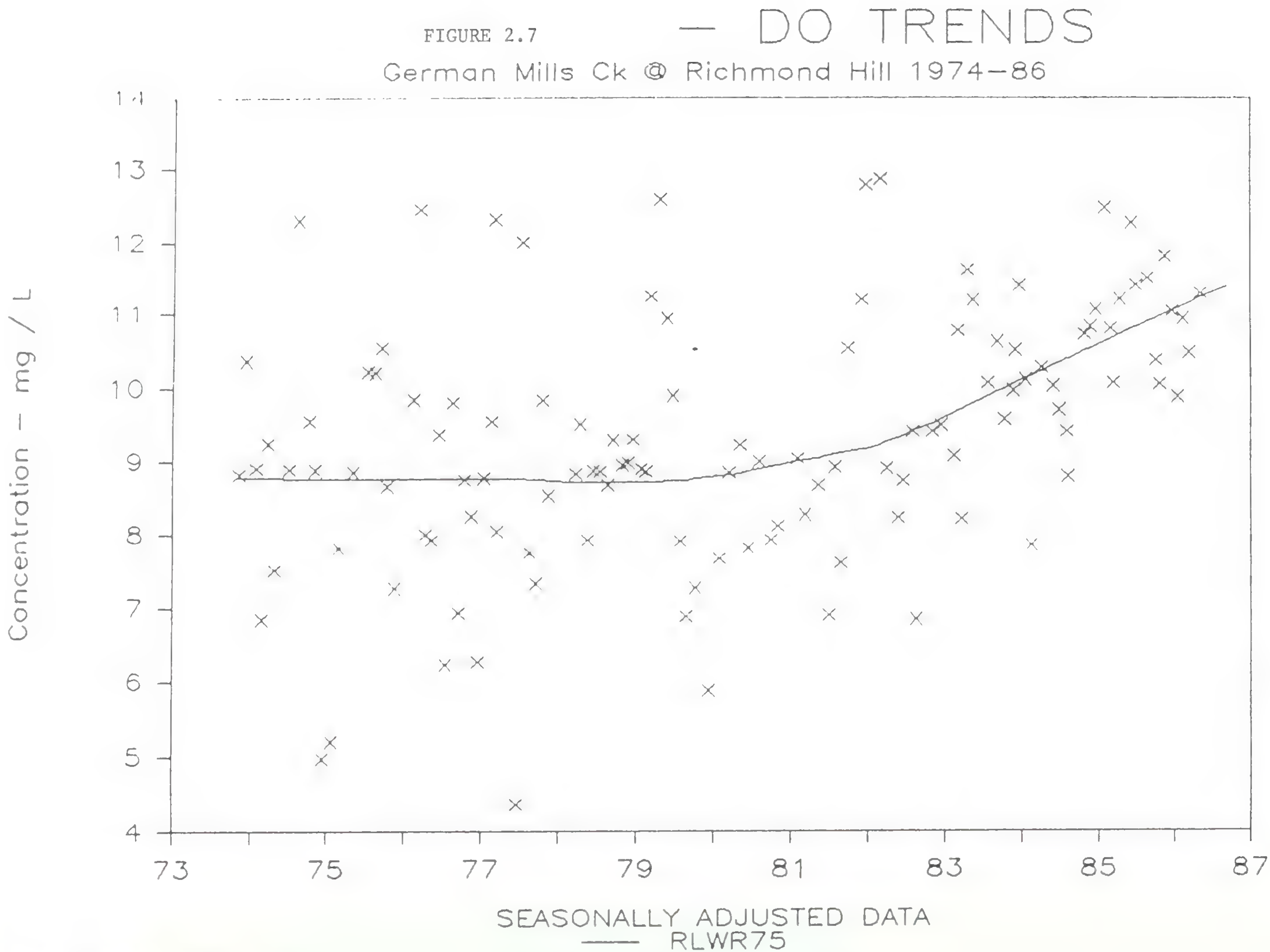
— DO TRENDS
W Don R @ Highway 7, 1974–86
Concentration – mg / L
16
15
14
13
12
11
10
9
8
7
6
5
4
73
75
77
79
81
83
85
87
SEASONALLY ADJUSTED DATA
RLWR75

Figure 2.6



— DO TRENDS
E Don R @ Bayview & Steeles 1974–86
Concentration – mg / L
14
13
12
11
10
9
8
7
6
73
75
77
79
81
83
85
SEASONALLY ADJUSTED DATA
RLWR75

FIGURE 2.7



— DO TRENDS
German Mills Ck @ Richmond Hill 1974–86
Concentration – mg / L
14
13
12
11
10
9
8
7
6
5
4
73
75
77
79
81
83
85
87
SEASONALLY ADJUSTED DATA
RLWR75

Figure 2.8

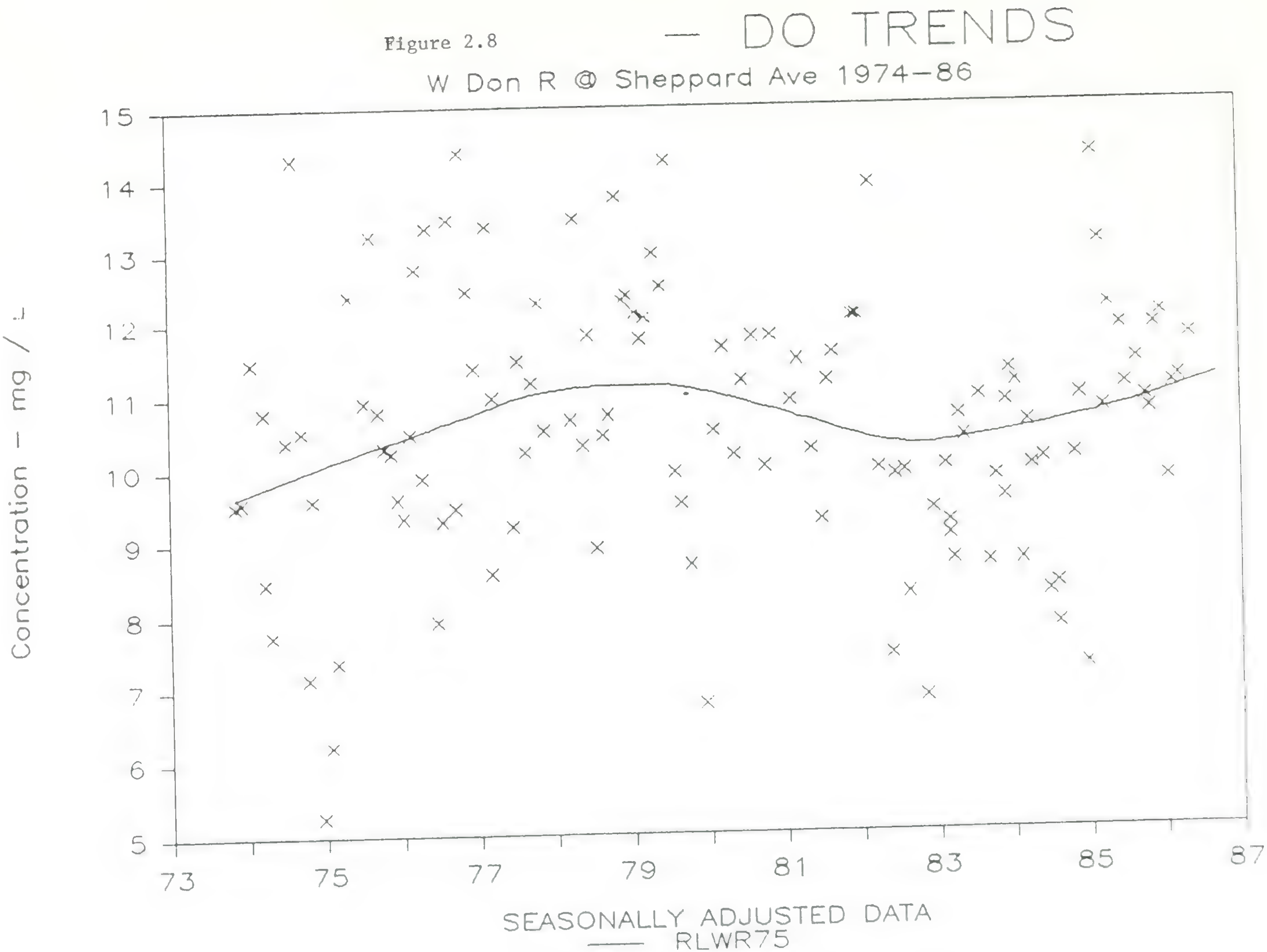

— DO TRENDS
W Don R @ Sheppard Ave 1974–86
15
14
13
12
11
10
9
8
7
6
5
Concentration – mg / L
73
75
77
79
81
83
85
87
SEASONALLY ADJUSTED DATA
RLWR75

FIGURE 2.9 — BOD TRENDS

Don R @ Lakeshore Blvd 1964–86

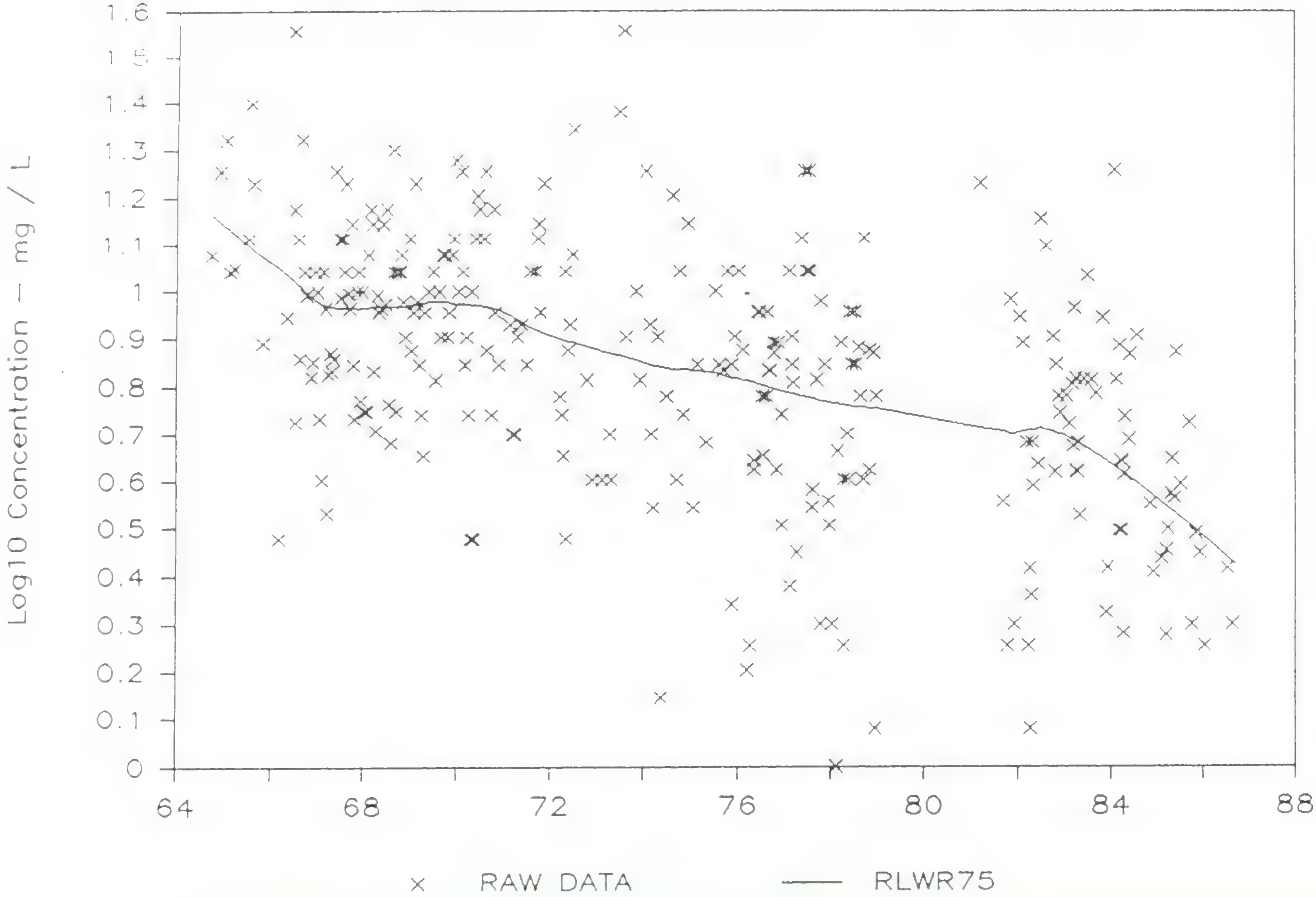
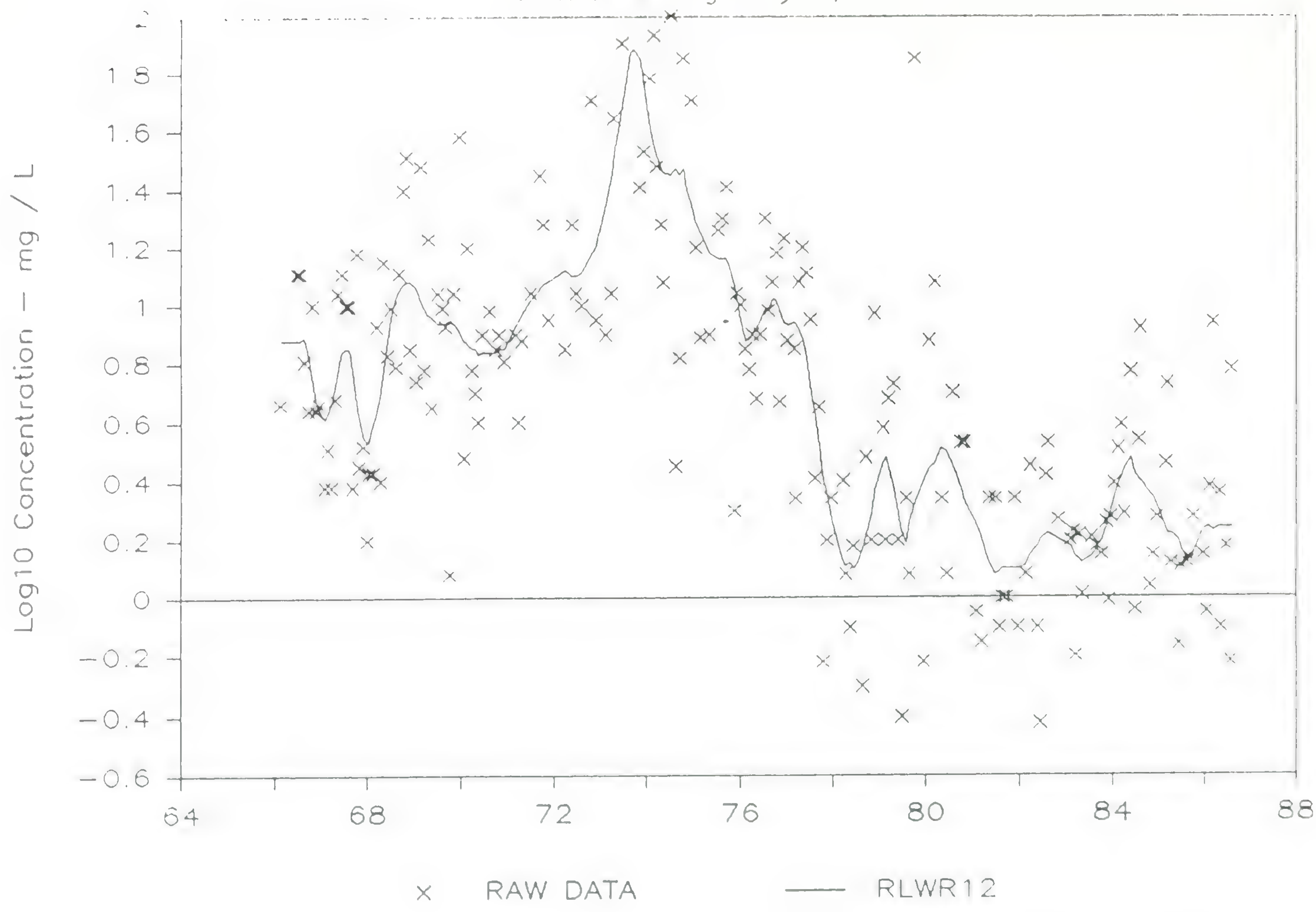


FIGURE 2.10

— BOD TRENDS

W Don R @ Highway 7, 1964–86



2.4 pH

Field measurements of pH are sparse, varying from 49 to 80 samples since 1979. Laboratory values of pH, which were measured over the period of 1966 to 1986, were rejected by Bodo due to lab values showing no consistent relationship to field values measured at the time of sampling.

The values generally do not violate the PWQO range of 6.5-8.5 with the exception of a few values which are too high or too low. Maximum values such as 9.4 and minimum values such as 5.2 in German Mills Creek could be an artifact of field measurements. It is doubtful that such a minimum (5.2) is real in a watershed which is well buffered because the water flows through the calcerious soils. Such values would result from acid spills or similar phenomena. Such causes of low pH values cannot be determined from monitoring data.

2.5 Alkalinity

PWQO objectives generally state that "alkalinity" should not decrease below 25% of natural levels. In the case of the Don River, the natural level and its seasonal variation is difficult to determine unless one goes to a similar watershed unimpacted by urban influences. Accordingly, Bodo concentrated upon assessment of low values of alkalinity in their role as establishing tolerance limits for metals such as lead.

In general, the alkalinity values in the lower Don River are greater than the 150 mg/L at Lakeshore Blvd. and greater than 90-100 mg/L in the Don River at Todmorden. There is a seasonal effect detectable at the two stations with a significant decrease in spring; this is probably due to snowmelt effects. At the other stations, too few samples have been measured to analyse for seasonal or annual trends. The observed minimum in the other branches is 90-100 mg/L as $CaCO_3$.

2.6 Suspended Solids and Turbidity

A correlation analysis indicated that there was a good, but noisy correlation between suspended solids and turbidity. The r^2 for data from the Lower Don @ Lakeshore was .28 while that for the Lower Don at Todmorden was .52. The confidence level indicated that

these r^2 values were significant, at the 99.99% level. The larger variability at the Lakeshore site may reflect the impact of small grain sediments from the lake and variations in flow complicating the analysis.

A trend analysis of suspended solids and turbidity data suggested a decrease over the period 1964-1986 at the Lakeshore Blvd. site, but no long term trend at the Todmorden site. Seasonal analyses were not presented due to the impact of flow upon suspended solids concentration. Due to the high background variability imposed by flow, Bodo judged that there was no trend over time.

Spatially, there were no great differences in suspended solids or turbidity between the six stations. At all sites, mean SS values varied within a range of 12 to 30 mg/L. Summary values are given in Table 2.1 to 2.6 for the 6 stations.

2.7 Conductivity, Chloride, Dissolved Solids

Spatial and seasonal patterns are summarized in Tables 2.1 to 2.6. Extensive analyses of the 3 parameters has been carried out for the Lower Don River stations at Lakeshore Blvd. and at Todmorden. Conductivity was analysed in some depth as a surrogate for the other two parameters at the other four stations.

The three parameters can generally be used as "tracers" of water movement and as an indicator of sources of contamination. However, neither of the three parameters is critical to aquatic life at levels commonly observed. There are no PWQO criteria for these three parameters. But Maximum Desirable Concentrations ("MDC"'s) can be established to reflect aesthetic considerations and requirements of domestic water users. Bodo (1987) selected MDC values of 500 mg/L for dissolved solids and 250 mg/L for chlorate. An MDC value of 1000 mg/L was also employed for dissolved solids to indicate a division between fresh and "slightly saline" water.

The seasonal analysis indicates that chlorides, dissolved solids, and conductivity peak in early January and decrease to summer lows in late summer. Exceedances of the 250 mg/L chloride MDC are approximately 0% (Figure 2.11) in early November, rise to peak at 90% about mid January and decline to 0% by early March (note the time axis is constructed as follows:

FIGURE 2.11

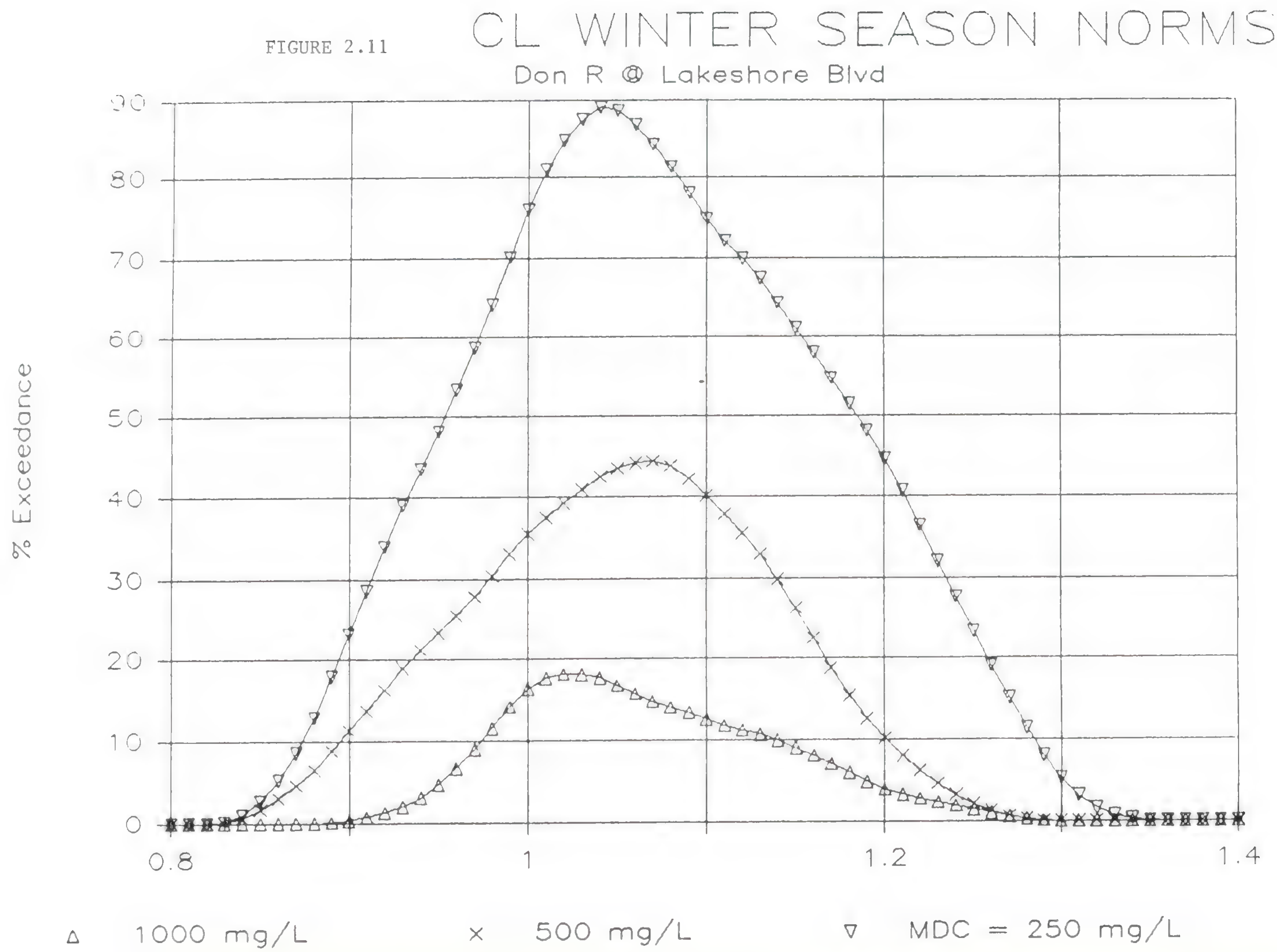
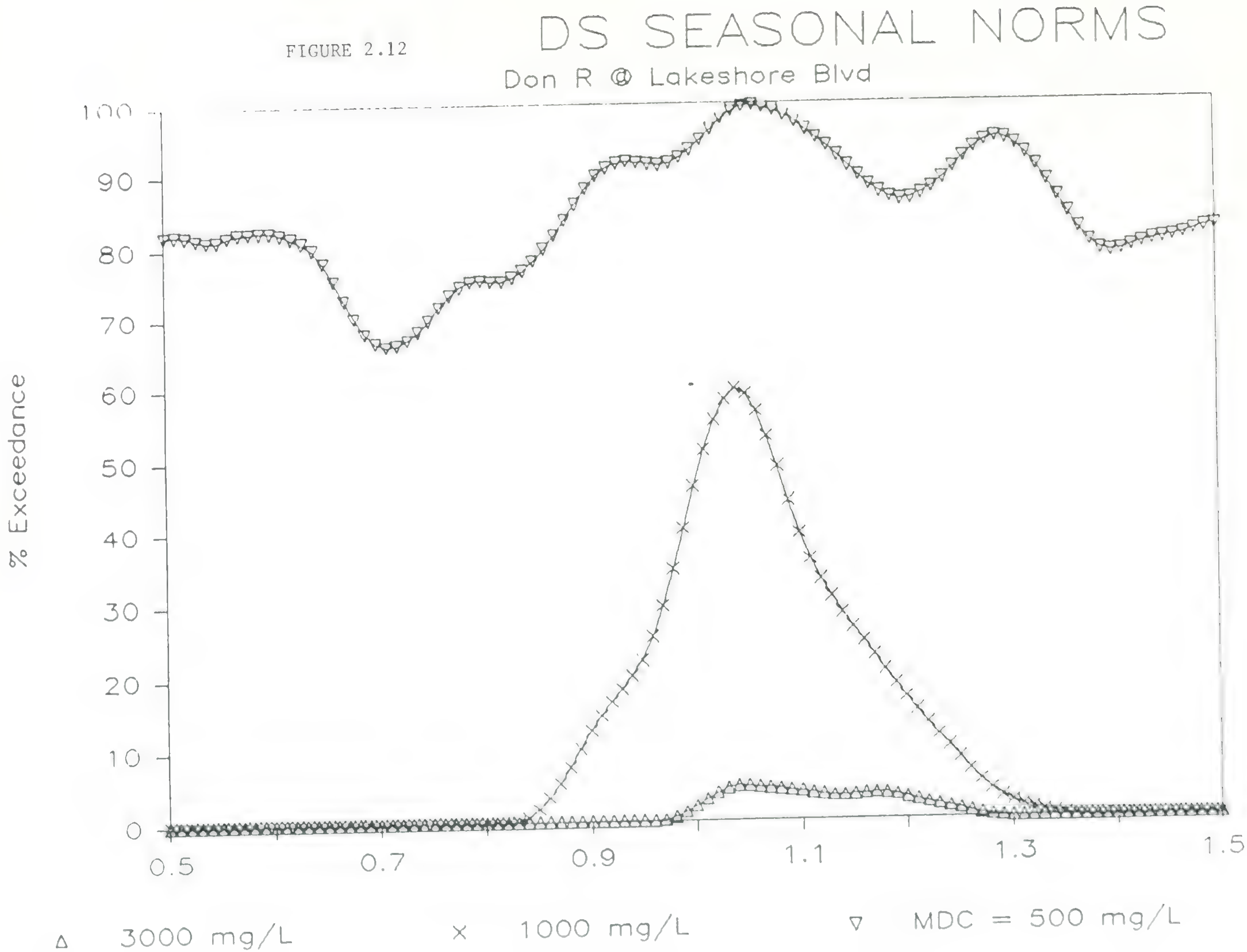

CL WINTER SEASON NORMS
Don R @ Lakeshore Blvd
% Exceedance
90
80
70
60
50
40
30
20
10
0
0.8
1
1.2
1.4
△ 1000 mg/L
× 500 mg/L
▽ MDC = 250 mg/L

FIGURE 2.12



DS SEASONAL NORMS
Don R @ Lakeshore Blvd
% Exceedance
100
90
80
70
60
50
40
30
20
10
0
0.5
0.7
0.9
1.1
1.3
1.5
Δ 3000 mg/L
× 1000 mg/L
∇ MDC = 500 mg/L

Graph Time	Time of Year
0.5	July 2
0.9	Nov. 24
1.3	Apr. 20

The maximum observed chloride value is 2480 mg/L. While these values are substantially below seawater, they clearly reflect the impact of urbanization upon typical "background" levels of 5-10 mg/L (as observed in the more prestine Saugeen River Basin). The "seasonal analysis for the Don River at Lakeshore shows a similar seasonality for dissolved solids (for an MDC of 1000 mg/L). Typically, more than 80% of the data exceeds an MDC of 500 mg/L over the complete year (Figure 2.12).

2.8 Microbiological Parameters (Fecal Coliforms)

Data are available for four indicator organisms. They are:

- o Total Coliforms (TC)
- o Fecal Coliforms (FC)
- o Fecal Streptococcus (FS)
- o Pseudomonas Aeruginosa (PSA)

Fecal coliforms and pseudomonas aeruginosa are the most important with Fecal Coliforms being the main parameter for swimming standards.

The data base contained a set of qualifiers including data which were less than or greater than, approximate values, and data which were measured after time delays between the time of sample collection and time of lab analysis. These approximations were classified and used in assessing the reliability of the associated data.

Long-term trends were assessed from total coliform data due to the brevity for some of the other parameters. Because there was consistant behaviour between TC, FC, and PSA, similar behaviour is expected in these parameters.

The following long-term trends are noted for TC (Bodo, 1987). Where frequencies of PWQO violations are noted, a 3-year window was used.

Table 2.7 Microbiology Data Summary
Don River PWQMN Sites, July 1982 - August 1986

Parameter		Lower Don 001	Lower Don 007	East Don 003	East Don 005	West Don 002	West Don 004
TC	n	64	42	42	42	43	41
	Q50	26000	17000	6950	8700	5000	3400
	GM	26800	14200	8390	10300	4780	4300
	% > 1000	98.4	85.7	97.6	97.6	86.0	80.5
FC	n	67	155	46	46	47	45
	Q50	1760	1000	1020	504	400	270
	GM	1790	895	1230	596	385	366
	% > 100	95.5	74.8	95.7	89.1	78.7	66.7
	% > 200	92.5	67.1	89.1	71.7	63.8	57.8
FS	n	67	138	46	46	47	45
	Q50	580	370	420	240	180	100
	GM	508	383	509	285	255	262
PSA	n		109				
	Q50		40				
	GM		65				
	% > 10		64.2 - 74.2*				

* Min-Max range according to limiting assumptions on 7 values of 20<

GM = geometric mean (computation included < and > values)

Lower Don River

1964-1969 - high TC (and by inference FC, FS and PSA) levels at Lakeshore Blvd. (site 001)

late 1969 - abrupt drop in TC levels at Lakeshore Blvd.

1970-1976 - stable period, median indicator levels higher at Lakeshore Blvd. than at Todmorden (site 007)

1977-1981/82 - steady rise in all indicators at both sites, peaking in the early 1980's withmedian TC counts and PWQO violation frequency approaching pre-1970 levels

1982/83-1986 - downward trend in median counts for all indicators at both sites, but PWQO violations remain high at Lakeshore Blvd.

East Don River

"The two upper east branch sites show generally similar trends" (Bodo, 1987).

Site 003: East Don River at Bayview and Steeles

1965-1975 - high median levels and PWQO violations
1976-1977 - steep rise in median levels
1978-1986 - downward trend to pre-1976 levels but less variability and PWQO violations remain high

Site 005: German Mills Creek at Richmond Hill

1965-1969 - high median levels
1969-1970 - downward trend
1971-1973 - low median levels
1974-1977 - sharp upward trend
1978-1986 - slight downward trend, levels remain high with reduced variability

"The rise in levels observed at both sites during the mid-1970's appears to have been associated with urban development (Bodo, 1987). The slight downward trends and reduced variability since 1978 may in part be attributable to upstream STP closings in late 1981 and to a certain extent, post-construction stabilization of developed areas."

West Don River

"Historical behaviour at the two West Don sites (002 at Sheppard Ave., and 004 at Highway 7) is similar (Bodo, 1987). The pattern at site 004 is outlined below:

1965-1974	-	increasing trend to high levels with high variability
mid-1974	-	abrupt drop in mean level
late 1976	-	abrupt rise in mean level
1977-1986	-	slight downward trend in median levels and PWQO violations."

"Downstream at site 002, the behaviour is similar except that the abrupt swings observed at site 004 have been damped considerably. Median levels and PWQO violations are generally higher downstream at Sheppard Ave."

Seasonal effects noted in Table 2.1 to 2.6 are based upon an analysis of data for the period July 1982 to August 1986 in which an intensive sample effort was undertaken. A summary of the data is given in Table 2.7. The worst median levels and violation statistics are observed at the Lakeshore site of the Don; levels at Todmorden (site 007) are slightly lower. The next worst sites, are in the East Don, with the East Don at Bayview and Steeles being slightly worse than German Mill Creek. The West Don sites are cleaner, but still quite contaminated; the upper most site (at Highway 7) is slightly cleaner than the West Don @ Sheppard.

2.9 Total Phosphorus

The PWQO for total phosphorus of 30 ug/L, which should "eliminate excessive plant growth in rivers and streams", is routinely surpassed in much of Southern Ontario. Accordingly, "maximum desirable concentrations" of 0.1 mg/L for flowing rivers and 0.05 mg/L for waters flowing into lakes and reservoirs have been suggested.

Trends and representative values are summarized over time in Tables 2.1 to 2.6; frequency of violations are summarized in Table 2.8. Phosphorus levels have declined generally since 1971 in the Lower Don River except for a significant rise in levels in the 1979-83 period, especially at the Don @ Todmorden site. A complete explanation for this rise was not given by Bodo, although heavy sampling of higher flows may have contributed to the rise in this period. In the East Don, phosphorus levels rose steeply during the 1960's, and remained at high levels in the early 1970's. Substantial declines occurred with the removal of STP's (mid 1975 and 1984 for German Mills; end of 1981 for East Don). In the West Don, the TP concentrations increased from the early 1960's to end of 1974 when an abrupt decline was followed by a general decline to level off in 1983-84.

The East Don presently has the lowest TP levels with the Lower Don having the highest levels (Table 2.8). All sites exceed the PWQO more than 80% of the time while a greater spectrum in violation statistics is obtained by using the EPA criteria. For example, for a criteria of 0.1 mg/L, the East Don data violates this criteria about 30% of the time while the Lower Don still violates the criteria more than 90% of the time.

For purposes of the Don River Water Quality management study, use of a less restrictive standard such as 0.1 mg/L is recommended to allow assessment of the degree of improvement resulting from control.

2.10 Nitrogen Compounds

Trends were assessed by Bodo (1987) for nitrate, total nitrate, TKN (total Kjeldahl N), ammonia and organic nitrogen after nitrogen anomalies (resulting from reactions occurring in the sample bottle) were removed from the data set.

For the Lower Don, there have been substantive declines in ammonia and TKN and an associated increase in nitrate. The increase in nitrate is due to more complete nitrification in the STP's and their discharge to receiving waters. However, the decline in TKN over the period of record exceeds the increase of nitrate resulting in a small decrease in total nitrogen discharged to the river system (e.g., given a decrease in mean total nitrogen at Lakeshore Blvd. from about 8 mg/L to 4 mg/L for the period 1966 to 1986).

Table 2.8 Phosphorus Criteria Violation Frequency
Don R PWQMN Sites: 1982-86

Site	n	Median (mg/L)	Percent Violations PWQO .03 mg/L	EPA .05 mg/L	EPA .10 mg/L
East Don					
005	50	.061	88	72	30
003	50	.071	84	58	32
West Don					
004	50	.091	100	82	64
002	50	.129	100	92	70
Lower Don					
007	182	.261	99.4	98.9	93.9
001	77	.190	98.7	98.7	89.6

For the East Don, significant decreases in ammonia, TKN and nitrate have resulted from closure of the STP's above the monitoring sites. However, opposite trends were noted before closure. All nitrogen species increased in concentration for the East Don @ Bayview/Steeles until plant closure, while ammonia and TKN species decreased in concentration for the German Mills site. This reflects better operation at the Richmond Hill Plant to achieve some removal of Total N and nitrification which resulted in increasing nitrate concentrations.

For the West Don, levels of both ammonia and TKN increased until an abrupt drop in 1976-1977 associated with closure of the STP. Nitrate levels have an associated increase; however, lack of nitrate measurements past 1980-81 preclude assessment of levels in the 1986 period.

The spatial data for 1983-1986 period is summarized in Table 2.9.

Violation statistics for the different sample sites are summarized in Tables 2.1 to 2.6 for the period 1983 to 1986. This is the only period for which field pH values are available. While field pH value may be suspect, this is the data base available and hence, must be used herein. The statistics indicate that PWQO for unionized ammonia was exceeded 37% of the time for the Lower Don at Lakeshore Blvd. and 17% of the time for the Lower Don at Todmorden, but that there were no violations in the East or West Don. No ammonia data have been obtained by us to characterize ammonia levels in Wilkett Creek/Massey Creek, areas suspected of having a fish toxicity problem caused by ammonia (see Section 2.2). This is a priority for future work.

With respect to other nitrogen species, there are no PWQO values for nitrite, nitrate or total Kjeldahl nitrogen based upon protection of aquatic life. However, values of 1 mg/L for nitrite and 10 mg/L for nitrate can be adopted as target values as the maximum acceptable concentration related to human health. Based upon these targets, there are several samples which exceed these nitrite values at all monitoring stations except the West Don at Sheppard. Only the lower two stations show exceedances for the period 1983-1986 because the upstream stations have had STP's removed (East/West Don) or because no data have been gathered (East Don) in this period.

Table 2.9 Nitrogen Data Summary: Don R PWQMN Sites, Sep 83 - Aug 86

Parameter		Lower Don		East Don		West Don	
		001	007	003	005	002	004
Ammonia	n	43	36	36	36	36	36
	Q50	1.460	.868	.047	.035	.158	.045
Organic N	n	39	36	36	36	-	36
	Q50	.750	.672	.400	.341	-	.522
TKN	n	39	37	36	36	-	36
	Q50	2.350	1.750	.485	.390	-	.600
NO_2^-	n	40	119	36	36	-	-
	Q50	.187	.172	.026	.023	-	-
NO_3^-	n	40	119	36	36	-	-
	Q50	1.446	1.530	.822	.406	-	-
NO_x	n	43	123	36	36	-	-
	Q50	1.810	1.860	.837	.430	-	-
Total N	n	39	37	36	36	-	-
	Q50	4.230	3.920	1.387	.887	-	-

n = sample size Q50 = median

For nitrate, there are no exceedances of 10 mg/L. There is one exceedance of 10 mg/L for the Don River at Todmorden station in the data base, in the 1981-1983 period, but it is discounted due to laboratory difficulties.

2.11 Metal Parameters

Stations where the different metal parameters have been routinely measured are given in Table 2.10. Because the PWQO/CWCG values are hardness dependent, a summary of hardness values is given in Table 2.11.

2.11.1 Arsenic

Arsenic data are available from Station 001, 002 and 004 of the PWQMN. The majority of values are less than detection limit of 1 ug/L with a few sporadic samples in the 1 to 6 ug/L range. These values are well below water quality objectives of 50 ug/L (CWQG) and 100 ug/L (PWQO). Analyses of suspended particulates which range from 3.5 to 6.8 ug As/g (median of 5.3 ug/g) are below the dredge spoil guideline of 8 ug/g.

Arsenic levels do not warrant further consideration in the Water Quality Management Study.

2.11.2 Cadmium

Cadmium has been measured at sites 001 (Lakeshore), 007 (Todmorden) and 002 (West Don @ Sheppard). Due to different detection limits over time, and the concentrations being near detection limit, difficulties are experienced with a trend analysis. Using an extreme analysis (period of samples in a 2 year window greater than 0.3 ug/L), the data suggest a decrease in trend over time, but the time base is too small to permit definitive conclusions. There is also a seasonal effect apparent in the data with exceedances greater than 50% of PWQO's being observed in the January to mid March period and during the month of October at the Todmorden site. The data recorded at Lakeshore is more sparse, but suggests a similar seasonality with frequency of PWQO violations being approximately greater than 90%. The TAWMS (1984) data also show an increase from Todmorden to Lakeshore, supporting the trend of the PWQMN data.

Table 2.10 Metals Records; Don R PWQMN Sites

Metal		Site 001	007	003	005	002	004
Arsenic	(As)	X				X	X
Cadmium	(Cd)	X	X			X	
Chromium	(Cr)	X				X	
Copper	(Cu)	X	X	X	X	X	X
Iron	(Fe)	X				X	X
Lead	(Pb)	X	X	X	X	X	X
Mercury	(Hg)	X	X				
Nickel	(Ni)	X					X
Zinc	(Zn)	X	X	X	X	X	X

Table 2.11 Hardness of Don River Waters

	Hardness as $CaCO_3$
Max	424
Q50	313
Min	146
n	30
% < 180	3.3

Table 2.12 Cadmium Summary Statistics, Don R PWQMN Sites 1980-86
Concentrations in µg/L

	Site		
Order Statistics	001	007	002
MAX	3.	1.7	4.
Q50	.4	.2<	.2<
MIN	.1<	.1<	.1<
n	93	175	61
% Exceedence			
% > 1.8*	3.2	0	1.6
% > 1.3*	3.2	.6	1.6
% ≥ 1.	10.8	3.4	3.3
% > .8	17.2	7.4	6.6
% ≥ .5	39.8	23.4	18.0
% ≥ .3	60.2	40.0	26.2
% ≥ .2**	68.8	41.1	47.5

* new CWQG's for very hard and hard waters
** assumes .3< µg/L results are between .2 and .3 µg/L

An analysis of particulate data suggests that the cadmium concentrations are all essentially particulate. Cadmium concentrations on particulate ((median 1.8 ug/g; range 0.55 to 3.2 ug/g) exceeded MOE dredge disposal guidelines (1 ug/g) in 6 of 7 samples.

2.11.3 Chromium

Chromium data are summarized in Table 2.13a (PWQMN), Table 2.13b (TAWMS Runoff Data) and Table 2.13c (TAWMS 1984 Lower Don). The PWQMN sites show modest decreases over time. A seasonal pattern is evident, opposite to that of flow and suspended matter. Low values are observed from November through April (median values of 8 ug/L) with peak concentration observed in late June through August (median value of 15 ug/L) at the Don River at Lakeshore Blvd. site.

Suspended particulate concentrations range from 45 to 110 ug chromium/g solids, with a median of 75.5 ug/g. All values exceed MOE dredged spoil guidelines of 25 ug/g.

None of the PWQMN values exceed the PWQO value of 100 ug/L total chromium. However, several of the seasonal values in the summertime exceed the new CWQG value of 20 ug/L (total chromium) to protect fish and 2 ug/L (total chromium) to protect all aquatic life including zooplankton and phytoplankton. The TAWMS data indicate that chromium values increase with flow rate and that approximately 20% of the samples exceed the PWQO in such surveys (Table 2.13c).

2.11.4 Copper

Data for copper from all six sites of the PWQMN are summarized in Table 2.14. The Lower Don has the highest values while the East Don has the lowest values. There are no conclusive trends evident in the short data set (1981 to 1986). There is a seasonal pattern evident in the data with peaks evident in spring and fall, a pattern associated with flow and suspended solids downstream (see Table 2.14b, 2.14c).

PWQO copper values (5 ug/L) are exceeded 80% of the time over the whole seasonal cycle while the new hardness related CWQG values of 4 ug/L (for a hardness greater than 180 ug/L which is typical of the Don (see Table 2.11) are exceeded even more frequently. From equilibrium chemistry considerations, most of the copper would be

Table 2.13a Chromium Summary Statistics
Don R PWQMN Sites, Jul 1983 - Aug 1986, Concentrations in μg/L

	Site	
Order Statistics	001	002
Max	91	83
Q90	19	9
Q50	12	4<
Q10	4	1<
Min	3	1<
n	45	37
Exceedence Statistics		
% > 2	100	70.3-75.7*
% > 20	6.7	6.1
% > 40	4.4	3.3
% > 100	0	0

* Min-Max range according to limiting assumptions on 2 values of 5< μg/L

Table 2.13b Chromium Summary Statistics: TAWMS Runoff Event Surveys, Concentrations in µg/L

A. TAWMS 1986 Survey: Don River at Todmorden

Order Statistics	Flow (m^3/s) Category ≤5	>5-≤10	>10-≤25	>25
Max	13	29	44	58
Q75	9	16	31	29
Q50	5<	13	16*	25
Q25	5<	10	13*	18
Min	5<	5<	5<	10
n	14	20	19(16*)	20
Exceedence Statistics				
% > 2	42.9-100**	89.5-100**	78.9-100**	100
% > 20	0	5.3	31.6-47.4**	65
% > 40	0	0	5.5	10

* calculated after removal of 3 values reported as 30< µg/L

** Min-Max ranges according to limiting assumptions on non-detect results

Table 2.13c

B. TAWMS 1984 Survey: Lower Don River

Order Statistics	Site 001	007
Max	170	190
Q75	79	81
Q50	58	75
Q25	54	48
Min	1<	1<
n	16	14
Exceedence Statistics		
% > 2	87.5	85.7
% > 20	87.5	78.6
% > 40	87.5	78.6
% > 100	18.8	21.4

Table 2.14a Copper Summary Statistics: Don R PWQMN Sites
Jul 83 - Aug 1986, Concentrations in µg/L

	Lower Don		East Don		West Don	
Order Statistics	001	007	003	005	002	004
Max	260	74	22	21	190	240
Q90	19	30	11	16	20	42
Q50	10	9	4	5	8	6
Q10	5	6	2	4	3	2
Min	3<	1<	1<	2	1<	1
n	45	125	38	35	37	38
Exceedence Stats						
% > 3	97.8	97.6	63.2	91.4	86.5	78.9
% > 4	88.9	96.	42.1	60.	70.3	71.
% > 5	82.2	92.	31.6	42.8	64.9	63.2

Table 2.14b Copper Summary Statistics: TAWMS Runoff Event Surveys, Concentrations in µg/L

A. TAWMS 1986 Survey: Don River at Todmorden

	Flow (m^3/s) Category			
Order Statistics	≤5	>5-≤10	>10-≤25	>25
Max	16	45	52	73
Q75	10	21	33	42
Q50	4	16	26	31
Q25	3<	9	22	17
Min	3<	3<	3<	3<
n	14	19	15	20

B. TAWMS 1984 Survey: Lower Don River

	Site	
Order Statistics	001	007
Max	140	140
Q75	120	110
Q50	86	95
Q25	67	61
Min	12	12
n	16	14

expected to be sorbed or particulate at the ambient pH of the Don. If the water quality standards were phrased in terms of "dissolved concentrations", and expected dissolved concentrations calculated from equilibrium considerations, the frequency of exceedance may be less.

It is proposed as an exercise for Phase II to choose an appropriate data record, reconstruct the probable % particulate/% soluble partitions for both copper and zinc, estimate an appropriate toxicity related limit for fish and other biota, and to estimate the frequency of exceedance.

The suspended particulate concentrations of 45 to 160 ug/g (median 100 ug/g) from the 7 PWQMN samples all exceed MOE dredge guidelines of 25 ug/g.

2.11.5 Iron

Iron data from three stations of the PWQMN exceed PWQO and CWQG values of 0.3 mg/L approximately 95% of the time (Table 2.15a) with no significant difference between concentrations at the three stations in the 1980's. Long-term data, available only at the Lakeshore site show a decline (median levels of 1.3 mg/L in the late 1960's to 0.7 mg/L in the 1980's). Levels at all three sites have been constant in the 1980's.

A seasonal pattern exists in the PWQMN data with high values in spring and full associated with flow and suspended solids patterns. Similar results were found in the TAWMS study (see Table 2.15b). Suspended particulate levels range from 29 to 36 mg/g with a median of 33 mg/g and exceed the MOE dredge spoil guidelines of 10 mg/g.

The data base available does not differentiate dissolved from particulate iron. Accordingly, it is difficult to determine if the exceedances are appropriate in relation to the rationale for PWQO formulation. Even in samples where "soluble levels" of iron are 0.3 to 0.4 mg/L in oxic systems, it is doubtful that they are truely dissolved, probably being colloidal in nature and hence, greater than 99% particulate. Only if complexed with humic substances would they be dissolved. The complexation by 3-6 mg/L TOC of such dissolved Fe levels is doubtful.

Table 2.15a Iron Summary Statistics: Don R PWQMN Sites, 1980-86
Concentrations in mg/L

Statistics	Site 001	Site 002	Site 004
Max	9.60	2[illegible].	14.[illegible]
Q90	3.46	2.24	3.10
Q50	.73	.74	.53
Q10	.45	.35	.32
Min	.16	.10	.26
n	86	67	[illegible]5
% > .3	97.6	[illegible]4.0	94.6

Table 2.15b Iron Summary Statistics: TAWMS Runoff Event Survey, Concentrations in mg/L

TAWMS 1986 Survey: Don River at Todmorden

Statistics	Flow (m^3/s) Category ≤ 5	$>5-\le 10$	$>10-\le 25$	>25
Max	4.9	13.	27.	39.
Q75	1.5	6.2	15.	20.
Q50	.99	3.7	11.	15.
Q25	.41	2.3	5.5	8.
Min	.32	1.1	3.	2.9
n	15	19	19	20

Hence, as an exercise to aid Phase II work, it is proposed to use the iron content of suspended matter of 33 mg/g and suspended solids concentrations to see how consistent the patterns in iron can be explained by suspended solids concentrations and to reflect upon appropriate ranges of values for different levels of protection. While the total concentrations are substantially higher than 0.3 mg/L, the particulate concentration is not substantially higher than dredge spoil guidelines, suggesting that the approach of using 0.3 mg/L as an objective is inappropriate unless the suspended solids concentration is also factored into the analysis.

2.11.6 Lead

Lead values show some degree of trend at two sites (increasing on the West Don @ Highway 7; and decreasing on the East Don at Bayview), but no significant trend in the Lower Don. Using extrema analysis similar to that made for cadmium, Bodo (1987) found a seasonal dependence related to the flow and suspended solids. This was confirmed by the TAWMS data (Table 2.16c).

Lead is mostly associated with particulate matter, but is occasionally soluble. Background levels of 3 ug/L are amplified by anthropogenic sources such as lead in gasoline. Much lead-gasoline combustion results in particulate lead emanating from the exhaust pipe. Water quality standards are alkalinity dependent (Table 2.16b). For alkalinity in the Don River, the CWQO standard of 7 ug/L would normally hold. For this value, more than 50% in the Lower Don and more than 30% of the samples in the East Don are exceeded (Table 7.16a)

Lead on suspended matter ranged from 100 to 270 ug/g with a median of 130 ug/g. All values exceeded the MOE dredge spoil guidelines of 50 ug/g.

For the Don River Water Quality Management Plan, it would be useful to include lead in the % particulate calculation proposed above for Cu, Fe and Zn. Because the equilibrium chemistry of Pb is complicated by both the possibilities of oxyhydroxides, hydroxocarbonates and anglesite, and the organic lead particulate form from gasoline, it is not proposed to include lead in such an evaluation.

Table 2.16a Lead Summary Statistics: Don R PWQMN Sites
Jul 83 - Aug 1986, Concentrations in μg/L

	Lower Don		East Don		West Don	
Order Statistics	001	007	003	005	002	004
Max	150	660	47	30	52	150
Q90	34	83	21	16	33	35
Q50	7	11	3	3	6	4
Q10	3	3<	3<	3<	3<	3<
Min	3<	3<	1<	3<	3<	3<
n	44	124	38	35	35	35
Exceedence Stats						
% > 4	72.7	71.	44.7	40.	51.4	45.7
% > 7	50.	61.3	34.2	28.6	42.9	37.1
% > 20	13.3	29.8	10.5	5.7	11.4	20.
% > 25	11.4	28.2	10.5	2.9	8.6	17.1

Table 2.16b Lead: Water Quality Criteria

Total lead concentrations should not exceed:

A. Provincial Water Quality Objectives (MOE, 1978)

Lead Concentration μg/L	Alkalinity mg/L as $CaCO_3$
5	< 20
10	20 - 40
20	40 - 80
25	> 80

B. Canadian Water Quality Guidelines (CCREM, 1987)

Lead Concentration μg/L	Hardness mg/L as $CaCO_3$
1	0 - 60
2	60 - 120
4	120 - 180
7	> 180

Table 2.16 c Lead Summary Statistics: TAWMS Runoff Event Surveys
Concentrations in µg/L

A. TAWMS 1986 Survey: Don River at Todmorden

Order Statistics	Flow (m^3/s) Category			
	≤5	>5-≤10	>10-≤25	>25
Max	110	100	220	230
Q75	30<	52	140	160
Q50	30<	30<	99	110
Q25	30<	30<	71	75
Min	15≤	16≤	32	30<
n	14	19	15	20

B. TAWMS 1984 Survey: Lower Don River

Order Statistics	Site	
	001	007
Max	370	350
Q75	240	290
Q50	200	190
Q25	77	43
Min	7	3<
n	16	14

2.11.7 Total Mercury

Total mercury values are summarized in Table 2.17a (PWQMN) and Table 2.17b (TAWMS). While trend analyses were made and while few values exceed the network objectives of 0.1 ug/L (2-3%) and 0.2 ug/L (2-20%; see Table 2.17a), few values are measured in the range of 5 to 30 ng/L (0.005 to 0.03 ug/L). This range of values appears to be a plausible range for contaminated systems; for example, the English Wabigoon River system, contaminated by pulp and paper mill discharges rarely gets above 30 ng/L total mercury concentration. Uncontaminated systems have values of the order of 1 ng/L, rather than the range of 10 to 100 ng/L referred to by Bodo. This suggests that the entire data base requires further assessment. Only if particulate mercury and suspended solids dynamics can explain levels measured are the data set plausible.

An analysis of suspended solids patterns, laboratory techniques, and the measured particle concentrations (levels ranging from 0.06 to 0.56 ug Hg/g in 6 samples with a median of 0.23 ug/g which compare reasonably with the dredge spoil guideline of 0.3 ug/g) are needed to check these points. For purposes of the Don River Water Quality Management study, mercury must be further disregarded, despite the levels observed in fish which have proximity to the MOE consumption guidelines of 0.5 ug Hg/g of fish.

2.11.8 Nickel

Nickel concentrations, measured at the Don River at Lakeshore and at the West Don River @ Highway 7 sites are higher at the downstream site (Table 2.18c). Levels increase from median values of 5 ug/L in 1982 to 1982 to 8 ug/L in 1985 to 1986 at the Lakeshore site. A similar increase is observed at the West Don site. Nickel concentrations are marginally dependent upon flow and suspended solids concentration (see Table 2.18c). This reflects the fact that most nickel concentrations have been observed to the soluble in surface water (Snodgrass, 1980).

The CWQC value for nickel is hardness dependent (Table 2.18b). For the Don River, the applicable value would be most frequently 150 ug/L, or occasionally 110 ug/L. Both values are higher than the PWQO of 25 ug/L. None of the observed values exceed the CWQC and few exceed the PWQO level, indicating the need not to consider nickel in this study.

Table 2.17a Total Mercury Summary Statistics, Lower Don River
Concentrations in μg/L

Period	1975 - 1978	Jul 1983 - Aug 1986	
Site	001	001	007
Max	.22	.95	5.6*
Q75	.14	.17	.04
Q50	.04	.04	.02
Q25	.03	.02	.01
Min	.02<	.01<	.01<
n	14	47	51
% > .1	28.6	31.9	2.
% > .2	7.1	21.3	[illegible]

* result is identified as a potentially erroneous outlier, next highest value is .1 μg/L

Table 2.17b Mercury Summary Statistics: TAWMS Runoff Event Surveys
Concentrations in μg/L

A. TAWMS 1986 Survey: Don River at Todmorden

	Flow (m^3/s) Category			
Order Statistics	≤5	>5-≤10	>10-≤25	>25
Max	.05	.4	.28	.58
Q75	.02	.05	.11	.15
Q50	.01	.03	.08	.09
Q25	.01<	.02	.07	.06
Min	.01<	.01<	.02	.04
n	14	19	15	20
Exceedence Stats				
% > .1	0	15.8	31.6	45.
% > .2	0	5.3	5.3	20.

Table 2.18a Nickel Summary Statistics
Don R PWQMN Sites, Jul 1983 - Aug 1986, Concentrations in µg/L

Order Statistics	Site 001	Site 004
Max	43	42
Q90	13	12
Q50	8	2
Q10	4	2<
Min	1	2<
n	40	33
% > 25	2.4	2.63*

* calculation based on data set of 38 including 5 values of 15< µg/L

Table 2.18b Canadian Water Quality Guidelines for Nickel

Hardness mg/L $CaCO_3$	Nickel Concentration µg/L
0 - 60	25
60 - 120	65
120 - 180	110
> 180	150

Table 2.18 c Nickel Summary Statistics: TAWMS Runoff Event Surveys, Concentrations in µg/L

A. TAWMS 1986 Survey: Don River at Todmorden

Order Statistics	Flow (m^3/s) Category			
	≤5	>5-≤10	>10-≤25	>25
Max	15<	15<	29	44
Q75	15<	15<	15	21
Q50	15<	15<	15<	19
Q25	15<	15<	15<	15<
Min	15<	15<	15<	15<
n	14	19	15	20
% > 25	0	0	6.7	20

B. TAWMS 1984 Survey: Lower Don River

Order Statistics	Site	
	001	007
Max	56	72
Q75	41	54
Q50	37	45
Q25	30	32
Min	4	4
n	16	14
% > 25	81.3	85.7

Suspended particulate levels range from 26 to 41 ug/g (median of 32 ug/g). All values exceed the MOE dredge spoil guidelines of 25 ug/g, but not by much.

2.11.9 Aluminum

There have been no aluminum data summarized by Bodo.. Accordingly, it is not considered for this study.

2.11.10 Zinc

A trend analysis indicates a small downward trend at the two Lower Don sites, the West Don at Sheppard and the East Don at Bayview and Steeles and a slight upward trend at the other two sites. All trends are over the period 1981-1986 except for the Lakeshore site which is over the 1975-1986 period. Only for the Lakeshore site is the data set long enough to give much confidence in the trends.

A seasonal component is noted in the PWQMN data with lowest values observed in the summer and highest values observed in February to March. No significant seasonal effect associated with fall norms/flows are noted. The strong spring dependency probably results from suspended solids and spring snow melt effects. The expected partition of zinc between suspended and dissolved phases also influences the seasonal pattern. The TAWMS data shows a stronger influence with flow (see Table 2.19b) and hence, suspended solids, than does the PWQMN data.

Approximately 20 to 40% of the observed values in the PWQMN data base and those associated with less than 5 cms in the TAWMS data base exceed the PWQO of 30 ug/L. About 100% of samples from flows greater than 5 cms exceed the PWQO. This dependence is explained in part, by the particulate forms of zinc. On particulate matter, the particle concentrations ranged from 54 to 420 ug/g with a median of 330 ug/g. Five of the 6 samples exceeded the MOE dredge spoil guideline of 100 ug/g.

Due to this frequency of violations, it is proposed that zinc be included in the analysis of the Don River Water Quality Management Plan.

Table 2.19b Zinc Summary Statistics: Don R PWQMN Sites
Jul 83 - Aug 1986, Concentrations in µg/L

	Lower Don		East Don		West Don	
Order Statistics	001	007	003	005	002	004
Max	250	320	97	120	140	100
Q90	56	148	49	48	36	53
Q50	25	23	8	26	22	20
Q10	19	13	2	12	7	11
Min	17	1	1	2	1	7
n	45	39	38	35	37	38
% > 30	31.1	28.2	18.4	40.	21.6	29.

Table 2.19b Zinc Summary Statistics: TAWMS Runoff Event
Surveys, Concentrations in µg/L

A. TAWMS 1986 Survey: Don River at Todmorden

	Flow (m^3/s) Category			
Order Statistics	<5	>5-<10	>10-<25	>25
Max	59	160	280	300
Q75	34	100	190	230
Q50	20	76	170	160
Q25	13	55	120	120
Min	8	34	29	89
n	15	19	15	20
% > 30	26.7	100	94.7	100

B. TAWMS 1984 Survey: Lower Don River

	Site	
Order Statistics	001	007
Max	610	630
Q75	480	550
Q50	360	400
Q25	300	260
Min	14	32
n	16	14
% > 30	93.8	100.

2.12 Herbicides, Pesticides and Industrial Organics in the Don River

A variety of herbicides, pesticides and industrial organics have been measured on the Don River (see Figure 2.13). A comprehensive list of chemicals measured (Table 2.20) their PWQO values (Table 2.21a) and their frequency of occurrence (Table 2.21 b, c) are attached. They include the following:

Chemical	Class
Aldrin	Pesticide
Dieldrin	Pesticide
Chlorodane	Pesticide
DDT and isomers (PP'-DDD, PP'-DDE)	Pesticide
Alpha BHC (BHC = hexachloroxyelohexane)	Pesticide
Beta BHC	Pesticide
Gamma BHC (also called Lindane	Pesticide
Endosulfan	Misc. Pesticide
Methoxychlor	Pesticide
Heptachlor; heptachlor epoxide	Misc. Pesticide
Atrazine	Herbicide
Phenoxyl Acid Herbicides	Herbicide
Carbaryl	-
Organophosphorus insecticides (e.g., parathion)	Pesticides
Carbonate pesticides	Pesticide
Chloroaromatus and chlorophenolics	Various; industrial organic
Reactive phenolics	Industrial organics
Dicamba	-
254-D-B	-
Diazinon	-
Guthion	-
PCB's	Industrial Organic
Mirex	Industrial Organic

Other chemicals for which data have not been summarized in terms of PWQO violations in TAWMS literature include dioxin, toluene, benzene and PAH compounds.

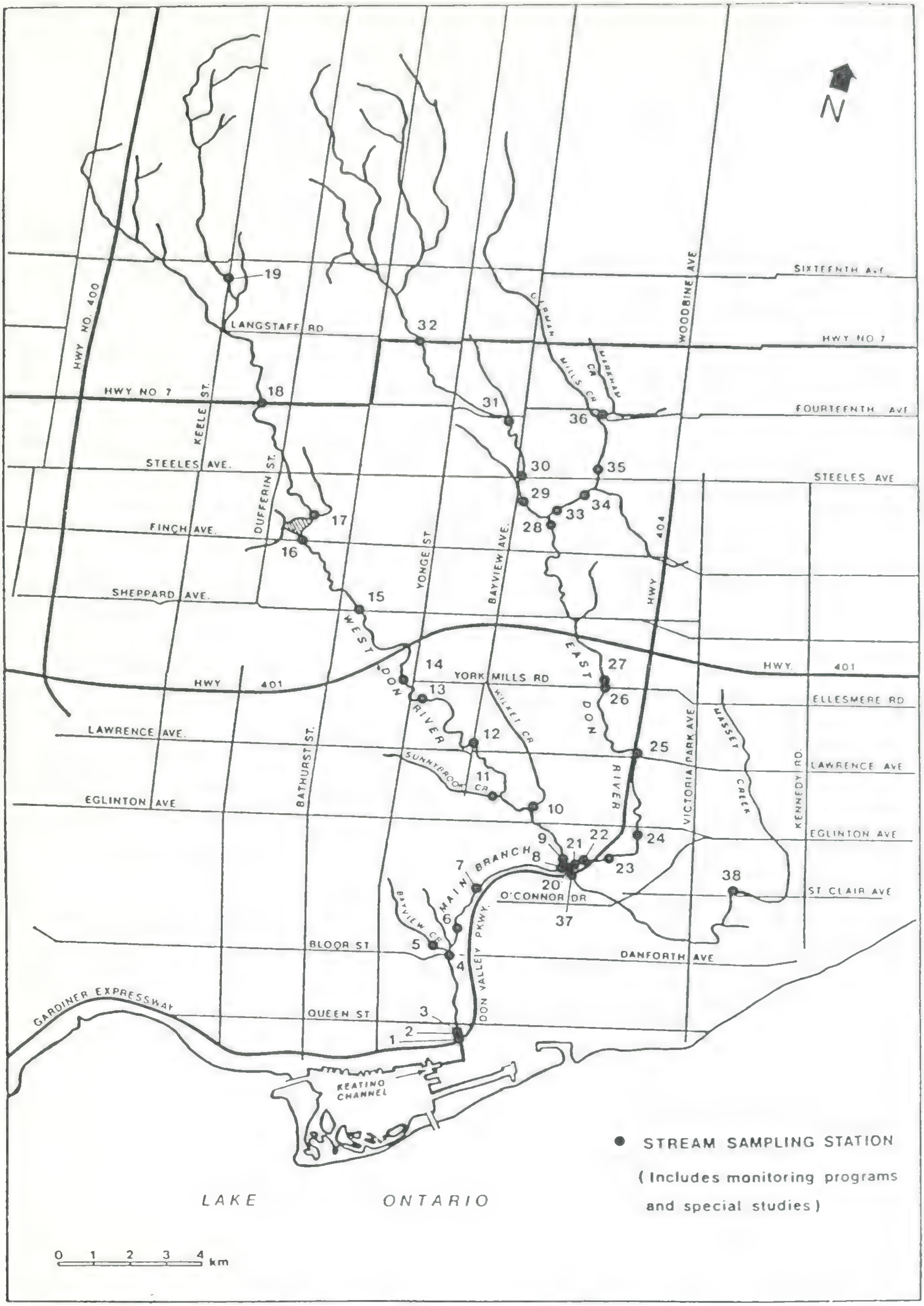


FIGURE 2.13: PESTICIDE AND INDUSTRIAL ORGANIC SAMPLING STATIONS ON THE DON RIVER AND TRIBUTARIES, 1979-1986

TABLE 2.20

INDEX TO PESTICIDES AND INDUSTRIAL ORGANICS TESTED IN THE DON RIVER AND TRIBUTARIES, 1979-1986

TEST NAME***	NAME	PARAMETER NUMBER
PESTICIDES AND INDUSTRIAL ORGANICS (OTHER)******		
CCNAUR	Cyanide, Available	1
CCNFUR	Cyanide, Free	2**
PCBT	Polychlorinated Biphenyls, Total; PCB (See Parameter 23)	
PHNOL	Phenolics, Reactive	3**
POCAPN	Captan	4
PCB AND ORGANOCHLORINE PESTICIDES		
P1ALDR	Aldrin	5**
P1BHCA	Hexachlorocyclohexane, Alpha; BHC α	6
P1BHCB	Hexachlorocyclohexane, Beta; BHC β	7
P1BHCG	Hexachlorocyclohexane, Gamma; BHC γ; Lindane	8**
P1CHLA	Chlordane, Alpha	9**
P1CHLG	Chlordane, Gamma	10**
P1DIEL	Dieldrin	11**
P1DMDT	Methoxychlor	12**
P1ENDR	Endrin	13**
P1ENDS	Endosulfan Sulfate; Thiodan S	14**
P1END1	Endosulfan 1 or Alpha; Thiodan 1	15**
P1END2	Endosulfan 2 or Beta; Thiodan 2	16**
P1HEPE	Heptachlor Epoxide	17**
P1HEPT	Heptachlor	18**
P1MIRX	Mirex; Dechlorane*	19**
P1OCHL	Oxychlordane	20
P1OCST	Octachlorostyrene (See Parameter 69)	
P1OPDD	OP-DDD	21**
P1OPDT	OP-DDT	22**

* Trade name.

** A PWQO or MOE guideline is available for these parameters (PWQO's and guidelines are listed on page xvii).

*** Test name codes used by the Ontario Ministry of the Environment Laboratory, Toronto.

**** Includes pollutants not categorized elsewhere.

NOTE: See also Index to Selected Trade Names, page xv.
Trade, scientific and common names were obtained from the following references: MOE 1987a, OMAF 1986, MOE 1981, Sine et al. 1987. Test names were taken from: MOE 1987.

TABLE 2.20

INDEX TO PESTICIDES AND INDUSTRIAL ORGANICS TESTED IN THE DON RIVER AND TRIBUTARIES, 1979-1986
(Cont'd)

TEST NAME***	NAME	PARAMETER NUMBER
PCB AND ORGANOCHLORINE PESTICIDES (Cont'd)		
P1PCBT	Polychlorinated Biphenyls, Total; PCB; Aroclor*	23**
P1PPDD	PP-DDD	24**
P1PPDE	PP-DDE	25**
P1PPDT	PP-DDT	26**
P1TOX	Toxaphene	27
X2HCB	Hexachlorobenzene; HCB*	28**
TRIAZINE HERBICIDES		
P2AMET	Ametryne	29
P2ATRA	Atrazine	30**
P2BLAD	Bladex*; Cyanazine	31
P2PROM	Prometone	32
P2PROP	Propazine	33
P2PROY	Prometryne	34
P2SENC	Sencor*; Metribuzin	35
P2SIM	Simazine	36
PHENOXY ACID HERBICIDES		
P3DICA	Dicamba	37**
P3PICL	Picloram	38
P3SILV	Silvex*; Fenoprop	39
P324D	2,4-Dichlorophenoxyacetic; 2,4-D	40
P324DB	2,4-Dichlorophenoxybutyric; 2,4-D-B	41**
P324DP	2,4-Dichloroprop; 2,4-D-P*	42
P3245T	2,4,5-Trichlorophenoxyacetic; 2,4,5-T	43
ORGANOPHOSPHORUS INSECTICIDES		
P4DIAZ	Diazinon	44**
P4DICH	Dichlorvos	45
P4ETHI	Ethion	46
P4GUTH	Guthion*; Azinphos-methyl	47**
P4MPAR	Methyl Parathion	48
P4MTRI	Methyl Trithion*	49
P4MEVI	Mevinphos	50
P4PARA	Parathion, Ethyl	51**
P4PHOR	Phorate	52
P4RONN	Ronnel	53

TABLE 2.20

INDEX TO PESTICIDES AND INDUSTRIAL ORGANICS TESTED IN THE DON RIVER, AND TRIBUTARIES, 1979-1986

(Cont'd)

TEST NAME	NAME	PARAMETER NUMBER
CARBAMATE PESTICIDES		
P6AMIN	Aminocarb	54
P6BENO	Benomyl	55
P6BUX	Bux*; Bufencarb	56
P6CARB	Carbofuran	57
P6HCAR	Carbofuran 3-HO	58
P6CARY	Carbaryl	59**
P6CIPC	CIPC*; Chloropropham	60
P6DIAL	Diallate	61
P6EPTM	Eptam*; EPTC	62
P6IPC	IPC*; Propham	63
P6PROP	Propoxur	64
P6SUTN	Sutan*; Butylate	65
P6*****	Barban; Carbyne*	66
CHLOROAROMATICS		
H2HCB	Hexachlorobenzene; HCB* (See Parameter 28)	
X1HCBD	Hexachlorobutadiene	67
X2HCE	Hexachloroethane	68
X2OCST	Octachlorostyrene	69
X2PNCB	Pentachlorobenzene	70**
X2T236	Trichlorotoluene 2,3,6	71
X2T245	Trichlorotoluene 2,4,5	72
X2T26A	Trichlorotoluene 2,6,A	73
X2123	Trichlorobenzene 1,2,3	74**
X21234	Tetrachlorobenzene 1,2,3,4	75**
X21235	Tetrachlorobenzene 1,2,3,5	76**
X2124	Trichlorobenzene 1,2,4	77**
X21245	Tetrachlorobenzene 1,2,4,5	78**
X2135	Trichlorobenzene 1,3,5	79**
CHLOROPHENOLICS		
X3PCPH	Pentachlorophenol; PCP*	80**
X3234	Trichlorophenol 2,3,4	81**
X32345	Tetrachlorophenol 2,3,4,5	82**
X32356	Tetrachlorophenol 2,3,5,6	83**
X3245	Trichlorophenol 2,4,5	84**
X3246	Trichlorophenol 2,4,6	85**

***** No current test name is available for Barban.

TABLE 2.20 (Cont'd)

INDEX TO PESTICIDES AND INDUSTRIAL ORGANICS TESTED IN THE DON RIVER AND TRIBUTARIES, 1979-1986

NOTES:

PARAMETER NUMBER - from the "Index to Pesticides and Industrial Organics tested in the Don River and Tributaries, 1979-1986", page xi.

PWQO - Provincial Water Quality Objectives designed for the protection of aquatic life and recreation.

MOE GUIDELINE - within Ministry aquatic criteria developed in a short-term urgent situation. Guidelines are not peer reviewed (expert review for scientific validity).

TYPE OF COMPOUND:

PARENT COMPOUND (P) - in this inventory, parent compounds are man-made compounds for utilitarian purposes.

DEGRADATION PRODUCT - a breakdown product.
METABOLIC (M) - a biologically induced breakdown product.
PHYSICAL (F) - a physically induced breakdown product.

ZTL - substances with zero tolerance limits (MOE 1984, Blue Book). A definition is available on page 72 of this report.

FOOTNOTES:

* Trade Name.

** For the purposes of this report, endosulfan sulfate is included in the PWQO for endosulfan, based on toxicological similarity (Worthing 1983).

*** MOE objective for forage fish for the sum of DDT and metabolites - 1000 NG/G (PPB) (MOE 1984, Blue Book).

**** MOE dredging guideline for PCB's - 50 NG/G (Persaud et al. 1976). 1978 International Great Lakes Agreement objective for forage fish for PCB's - 100 NG/G (IJC 1978).

***** It appears likely that chlorobenzenes can be produced by a physical process (MacLaren Plansearch 1984). There are no known natural sources.

****** It appears probable that chlorophenols can be produced from physical/metabolic processes as indicated (IEC Beak 1984).

SOURCES:

PWQO's; MOE 1984, Blue Book; Bazinet 1987a.
MOE Guidelines: Bazinet 1987a.
Type of Compound:
- Parameters 2-59: Bazinet 1987.
- Parameters 70-79: MacLaren Plansearch 1984.
- Parameters 80-85: IEC Beak 1984.

TABLE 2.21a

INVENTORY OF PROVINCIAL WATER QUALITY OBJECTIVES (PWQO)

PARAMETER NUMBER	NAME	PWQO (NG/L, PPT)	PWQO INTERPRETATION	TYPE OF COMPOUND PARENT COMPOUND ↓	DEGRADATION PRODUCT ↓
2	Cyanide, Free	5,000		P	
3	Phenolics, Reactive	1,000		P	M,F
5	Aldrin	1	(Sum of Aldrin and Dieldrin)	P	
8	BHC γ; Lindane	10		P	
9	Chlordane α	60	(PWQO is for Chlordane)	P	
10	Chlordane γ	60	(PWQO is for Chlordane)	P	
11	Dieldrin	1	(Sum of Aldrin and Dieldrin)		M
12	Methoxychlor	40		P	
13	Endrin	2		P	
14	Endosulfan Sulfate	3	(PWQO is for Endosulfan)**		M
15	Endosulfan α	3	(PWQO is for Endosulfan)	P	
16	Endosulfan β	3	(PWQO is for Endosulfan)	P	
17	Heptachlor Epoxide	1	(Sum of Heptachlor and Heptachlor Epoxide)		M
18	Heptachlor	1	(Sum of Heptachlor and Heptachlor Epoxide)	P	
19	Mirex	1	ZTL	P	
21	OP-DDD	3	(Sum of DDT and metabolites)*** ZTL		M
22	OP-DDT	3	(Sum of DDT and metabolites)*** ZTL	P	
23	PCB	20	**** ZTL	P	
24	PP-DDD	3	(Sum of DDT and metabolites)*** ZTL		M
25	PP-DDE	3	(Sum of DDT and metabolites)*** ZTL		M
26	PP-DDT	3	(Sum of DDT and metabolites)*** ZTL	P	
28	HCB*	6.5		P	
30	Atrazine	45,000....	(MOE guideline)	P	
37	Dicamba	200,000		P	
41	2,4-D-B	4,000		P	
44	Diazinon	80		P	
47	Guthion*; Azinphos-methyl	5		P	
51	Parathion, Ethyl	8		P	
59	Carbaryl	1,300....	(MOE guideline)	P	
70	Pentachlorobenzene	30		P	F *****
74	Trichlorobenzene 1,2,3	900		P	F *****
75	Tetrachlorobenzene 1,2,3,4	100		P	F *****
76	Tetrachlorobenzene 1,2,3,5	100		P	F *****
77	Trichlorobenzene 1,2,4	500		P	F *****
78	Tetrachlorobenzene 1,2,4,5	150		P	F *****
79	Trichlorobenzene 1,3,5	650		P	F *****
80	Pentachlorophenol; PCP*	500		P	F ******
81	Trichlorophenol 2,3,4	18,000		P	F ******
82	Tetrachlorophenol 2,3,4,5	1,000		P	F ******
83	Tetrachlorophenol 2,3,5,6	1,000		P	F ******
84	Trichlorophenol 2,4,5	18,000		P	M,F ******
85	Trichlorophenol 2,4,6	18,000		P	M,F ******

Table 2.21 b PWQO VIOLATIONS IN ROUTINE MONITORING (1981-86) AND SPRING SNOWMELT RUNOFF STUDIES (1984), DON RIVER[1] (PARAMETERS 1-28)

STUDY/PROGRAM: ADDITIONAL INFORMATION:		PWQO[3]	VALUE EXCEEDED	ROUTINE MONITORING[2] MAIN BRANCH	ROUTINE MONITORING[2] WEST BRANCH	SPRING SNOWMELT RUNOFF STUDIES ALL BRANCHES
PARAMETER						
2	Cyanide, Free	5000	5000	--	10% (N=10[4])	--
3	Phenolics, Reactive	1000	1000	77%	32%	--
5-6	Aldrin and Dieldrin	1	1	9%*	0%*	--
			3	4%-6%	0%	--
			4.2	--	--	30%*
			6.9	--	--	5%* (Max.13)
8	Hexachlorocyclohexane Gamma (BHC γ; Lindane)	10	10	32%	4%	23%
9-10	Chlordane α and γ	60	60	1%	0%	0%
12	Methoxychlor	40	40	0%	0%	23%
13	Endrin	2	4	1%	0%	--
			4.5	--	--	0%
14-16	Endosulfan α, β and Sulfate	3	3	5%*	0%*	11%*
			10	1%-2%	0%	--
			13.5	--	--	2%-5%

Table 2.21 b . PWQO VIOLATIONS IN ROUTINE MONITORING (1981-86) AND SPRING SNOWMELT RUNOFF STUDIES (1984), DON RIVER[1] (PARAMETERS 1-28) (Con't)

STUDY/PROGRAM: ADDITIONAL INFORMATION:		PWQO[3]	VALUE EXCEEDED	ROUTINE MONITORING[2] MAIN BRANCH	ROUTINE MONITORING[2] WEST BRANCH	SPRING SNOWMELT RUNOFF STUDIES ALL BRANCHES
	PARAMETER					
17-18	Heptachlor Epoxide and Heptachlor	1	1	4%*	0%*	--
			2	2%-4%	0%	--
			3.9	--	--	3%*
			7.6	--	--	0%-1%
19	Mirex	1	1	--	--	0%
			5	1%	0%	0%
21, 24-26	DDT: op'-DDT, op'-DDD, pp'-DDD, pp'-DDE, pp'-DDT	3	3	5%*	0%*	41%*
			16	1%-3%	0%	3%* (Max. 17%)
23	Polychlorinated Biphenyls (PCB) (1984-86)	1	20	8%	3%	--
			50	4%	3%	0%
28	HCB	6.5	6.5	4%	0%	0%

NOTES:

Important Note: Where possible, PWQO violations are provided. Where detection limits exceed the PWQO, exceedences of selected values are given. Detection limits vary between routine monitoring and spring snowmelt runoff studies.

NOTES: (Cont.)

- All values are in ng/L (ppt)
* The value given represents known exceedences and is a minimum.

1. Refer to text for interpretational information.

2. Provincial Water Quality Monitoring Network (PWQMN)
   Note: Includes sites monitored on a routine basis only.

3. Provincial Water Quality Objectives (PWQO's) designed for the protection of aquatic life and recreation.

4. The total number of samples is provided where N<20.

5. PWQO violations:
   A - Dry Event Survey (tributaries); 14%
   B - Wet Event Survey (tributaries); 100%
   C - Wet Event Survey (Main Branch); 88%

Table 2.21c PWQO VIOLATIONS IN WATER QUALITY PROGRAMS AND STUDIES, DON RIVER[1]
(PARAMETERS 29-85) (Con't)

PARAMETER	PWQO[2]	PWQO VIOLATIONS	TOTAL SAMPLES
80 Pentachlorophenol	500	9%	98
81 Trichlorophenol 2,3,4	18,000	0%	23
82 Tetrachlorophenol 2,3,4,5	1,000	0%	20
83 Tetrachlorophenol 2,3,5,6	1,000	0%	20
84 Trichlorophenol 2,4,5	18,000	0%	23
85 Trichlorophenol 2,4,6	18,000	0%	23

NOTES:

- All values are in ng/L (ppt).
* Trade name
[1] Refer to text for interpretational information.
[2] Provincial Water Quality Objectives (PWQO's) designed for the protection of aquatic life and recreation.

Table 2.21 c PWQO VIOLATIONS IN WATER QUALITY PROGRAMS AND STUDIES, DON RIVER[1]

(PARAMETERS 29-85)

PARAMETER	PWQO[2]	PWQO VIOLATIONS	TOTAL SAMPLES
37 Dicamba	200,000	0%	23
41 2,4-D-B	4,000	0%	24
44 Diazinon	80	0%	4
47 Guthion*; Azinphos-Methyl	5	0%	4
51 Parathion, Ethyl	8	0%	4
70 Pentachlorobenzene	30	1%	87
74 Trichlorobenzene 1,2,3	900	0%	87
75 Tetrachlorobenzene 1,2,3,4	100	1%	87
76 Tetrachlorobenzene 1,2,3,5	100	0%	87
77 Trichlorobenzene 1,2,4	500	0%	87
78 Tetrachlorobenzene 1,2,4,5	150	0%	87
79 Trichlorobenzene 1,3,5	650	0%	86

There are also no measurements of oil and grease or similarly related parameters which could be used as an indicator of oil slicks, gasoline spills or similar types of aesthetic problems on the Don River. Such organic compounds may be included in DOC measurements, but should constitute a small fraction of total DOC, conducting that DOC is an inappropriate parameter for assessing these compounds. Development of such a data base would be useful to aid future development of a water quality management plan. Oil and grease cannot be included in this assessment unless the MOE has a data base not available to us.

2.12.1 Chemical Levels and Frequency of Violation

The levels of the different chemicals are summarized herein in relationship to their frequency of violation of PWQO's.

In the regular monitoring program from1979-1986, violation statistics have been reported for the main branch and the west branch. In the main branch, the following summarize the violation statistics:

1) Significant violations (frequency not specified)

- lindane
- reactive phenolics (Figure 2.14a)

2) 1 to 9% violations

- endosulfur
- heptachlor/heptachlor epoxide
- DDT and metabolites
- PCB's (Figure 2.14b)
- Endrin
- Mirex

3) Less than 5% violations

- methoxychlor
- HCB
- Chlordane

In the west branch, the following statistics were observed in the regular monitoring program:

1) Substantive violations of PWQO

- reactive phenolics
- free cyanide (1 in 10)

2) Few violations of PWQO's

- lindane - 4%
- PCB's - 3%
- Others - no violation

Other compounds such as atrazine and carbaryl were also monitored in the West Branch, but they were not considered because only 4-5 samples were measured, because there were no exceedances of MOE guidelines, and/or because there were no PWQO values for these compounds.

Other compounds were measured in the main branch in various other programs and studies from 1979 to 1986 including atrazine, phenoxy acid herbicides, organophosphorus insecticides, carbonate peticides, chloro-aromatics and chlorophenolics. The PWQO values and violation statistics for representative compounds from these classes of herbicides, pesticides and industrial organics (see Table 2.21 b, c) indicate violations of less than 0-1% are evidence for all compounds except for PCP which were of the 9% level. It was noted that all PCP violations occurred prior to 1983.

In snowmelt runoff studies, violation statistics were higher than the routine monitoring data for the following compounds:

- DDT and Metabolites (mainly DDE),
- Aldrin/Dieldrin,
- Methoxychlor,
- Alpha and Beat - BHC, and
- Alpha Chlordane.

Some trends are also apparent in the data. Reactive phenolics (since mid 1960's) (see Figure 2.14a) and PCB (since initiation of their monitoring in 1979) (see Figure 2.14b) have decreased over the monitoring period. PCB levels may have decreased from the 1979 to 1982 period to the 1983 to 1986 period (based on 20 samples in the latter period), but more data are required to validate these results. Also, HCB levels were significantly lower in 1984-1986 compared to 1981-1983. On the other hand, methoxychlor increased from "no detections" to being detectable since 1985 (in 7 samples since 1985). Not included in the trend analysis is an analysis of changes in instrumentation, detection limits and their effect upon the trend analysis.

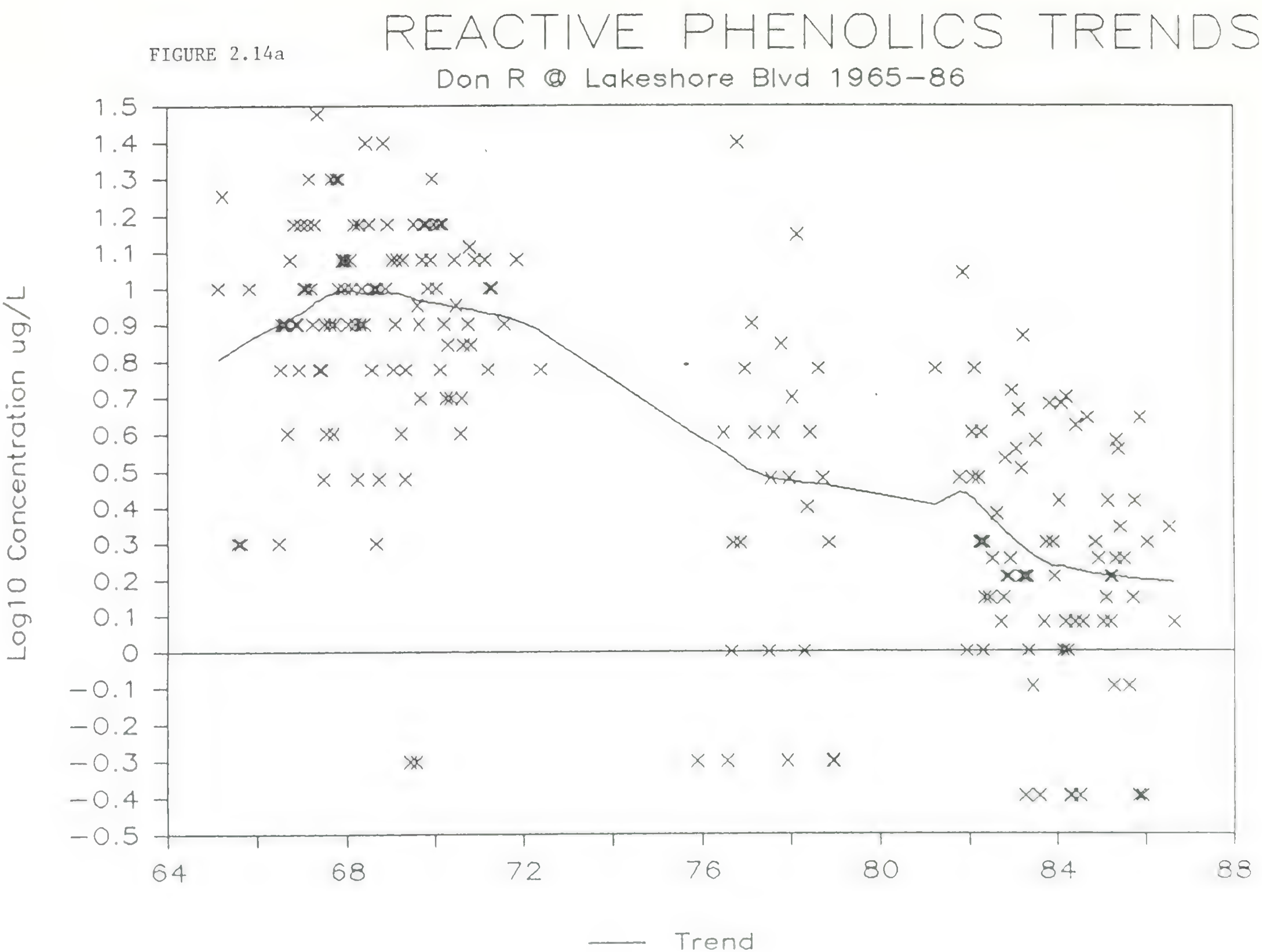
Fish in the Lower Don have also been analysed for various organics. Reported data indicate that PCB's in forage fish exceeded IJC objectives for all fish but that there was no exceedances for DDT and metabolites. Because PCB's are surface active and hence contained mainly in sediments, the major PCB pathways to fish is from sediments. Sediment analyses indicated that only 1 sediment sample exceeded the MOE dredging guideline for PCB's. An analysis of the life history of the fish analysed in the study is required, because much of their PCB body burden could result from uptake of PCB's during the portion of their life cycle in Lake Ontario.

2.12.2 Sources of Various Compounds

Phenolics

Phenolic compounds are a complex group of benzene derivatives whose properties are determined largely by their chemical structure. They may be from a natural source through the breakdown of humic material or arise as a by-product of industrial activity. Because of the diversity of individual phenolic compounds, a simplified test procedure is routinely used by the Ministry of the Environment to measure the concentration of "reactive phenolics" rather than concentrations of individual compounds. Individual compounds can be determined but the procedure is more complex and time-consuming.

FIGURE 2.14a



REACTIVE PHENOLICS TRENDS
Don R @ Lakeshore Blvd 1965–86
Log10 Concentration ug/L
1.5
1.4
1.3
1.2
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
−0.1
−0.2
−0.3
−0.4
−0.5
64
68
72
76
80
84
88
Trend

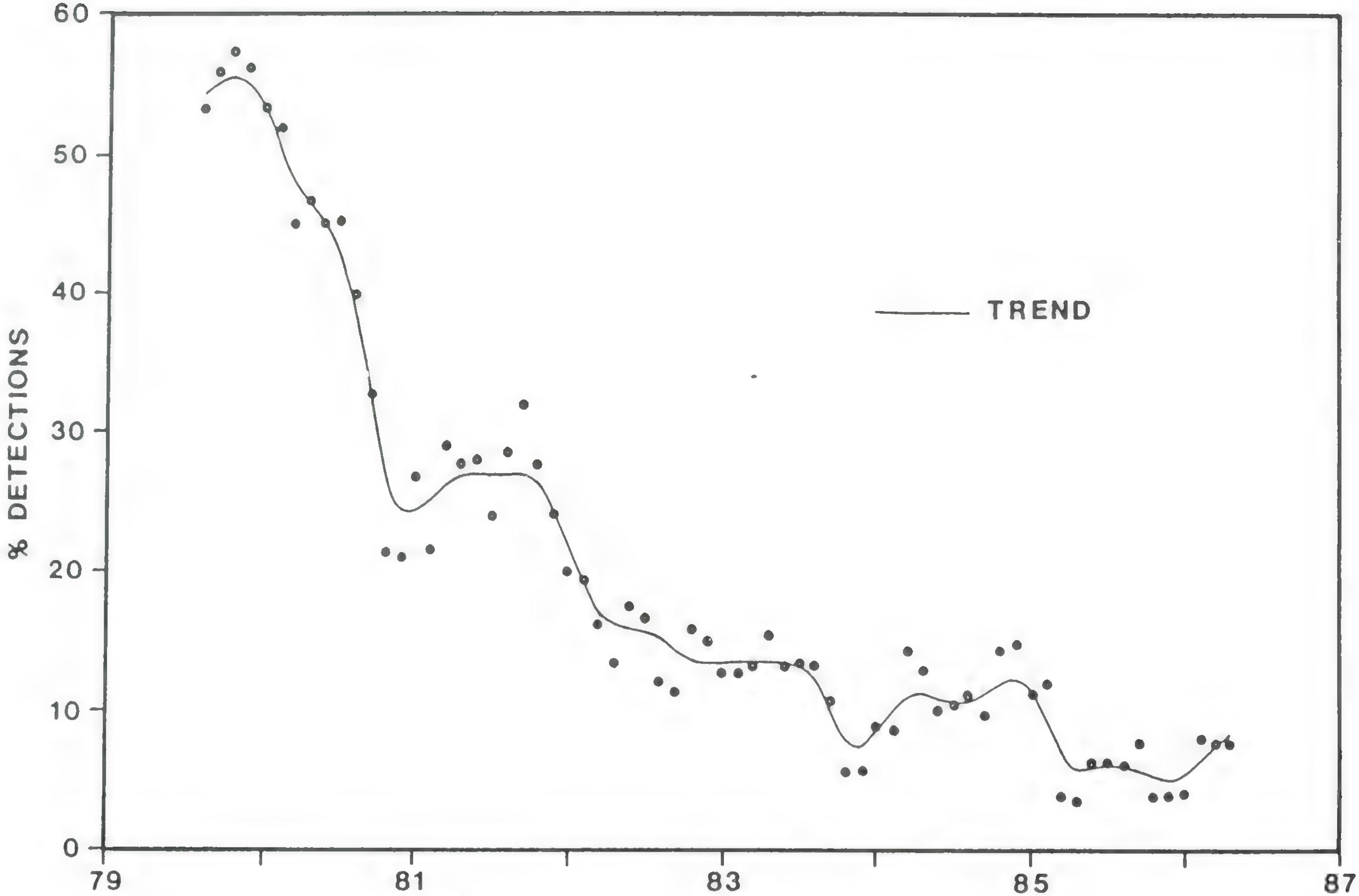


Figure 2.14b PCB Detection Rate, Lower Don River (Sites 1 and 7), 1979-1986.

Aldrin, Dieldrin, and Chlordane

Because spring snowmelts contained higher levels of these compounds than runoff over the remainder of the year, Zubovits (1987) suggested that their association with eroded soil is the most likely pathway for entering surface water, especially for dieldrin.

Dieldrin levels are much higher in the southern part of Toronto than in the upper Don River (see figure 2.15a). Similar patterns are apparent for alpha chlordane (Figure 2.15b).

Aldrin, dieldrin, and chlordane are used as insecticides on agricultural/garden areas and as termite control insecticides (Zubovits, 1987). Chlordane is not registered for any other use than termite control in Southern Ontario. Places where groundskeeping was extensively practiced are also a source.

Zubovits (1987) infers that such practices were the cause of high pesticide levels in neighbourhoods such as Rosedale, Parklane, Highpoint Road, the Bridle Path, the middle and upper parts of Bathurst Street and Bayview-Leslie area. The large termite infested area south of the junction of the Don River and Taylor Creek to Lake Ontario has the heaviest level of infestation in Toronto, resulting in the treatment of entire streets. Many treatments involve inside and outside treatment. Traditional methods still used currently in many applications, involve outside surface spraying. Only in the past 4-5 years have guidelines been issued mandating application mainly to the deeper regions of soils. Such type of application aids the surface mobilization and transport of the chemicals.

Rendered levels of these compounds are expected for several decades. Chlordane persists for approximately 15 years. Aldrin decays to dieldrin what persists for 20 to 30 years. These compounds continue to be used, although widespread chlordane usage was recently restricted (presumable for garden pets). Zubovits (1987) notes that Dursban TC is supposed to replace these compounds in the near future and that development of different biological insecticides is in progress.

TABLE 2.22 ACUTE LETHALITY AND TAINTING CONCENTRATIONS OF SELECTED PHENOLIC COMPOUNDS TO FISH

Compound	Rainbrow Trout 96 hr LC50 (ug/L)	Fish Tainting Concentrations Threshold (ug/L)	Range (ug/L)	Toxicity Data Reference
Phenol	8900	NA		U.S. EPA, 1978
2-Methylphenol	8400		400-200	DeGraeve, 1980
4-Methylphenol	7500	120		Hodson, et al., 1984
2,4-Dimethylphenol	17000 (FHM)	1000		Phipps et al., 1981
2,3,6-Trimethylphenol	138,200 (GPY)	NA		Saaridoski & Viluksela, 1981
4-Nitrophenol	7900	10,000		Hodson et al., 1984
2-4-Dinitrophenol	620 (BGS)	NA		
2-Chlorophenol	2100	24 (GM)	15-60	PPRIC, 1979
3-Chlorophenol	10,000 (48 hr)	45		Shumway & Palewsky, 1973
4-Chlorophenol	3830 (BGS)	51 (GM)	45-60	Boccaffusco et al., 1981
2,4-Dichlorophenol	2800	2.3 (GM)	0.4-14	PPRIC, 1979
2,6-Dichlorophenol	5000	6 (GM)	1-35	Applegate et al., 1957
2,4,6-Tricholophenol	1020	7 (GM)	1-52	PPRIC, 1979
2,3,4,6-Tetrachlorophenol	140 (BGS	NA		Boccafusco et al, 1981
1,2,5,6-Tetrachlorophenol	170 (BGS)	NA		Boccafusco et al, 1981
Pentachlorophenol	97	Lethal before tainting		Shumway & Palewsky, 1973

FHM - fathead minnow
BGS - bluegill sunfish
GPY - common guppy
NA - not available
GM - geometric mean
LC50 - concentration lethal to 50% of the exposed population

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DIELDRIN

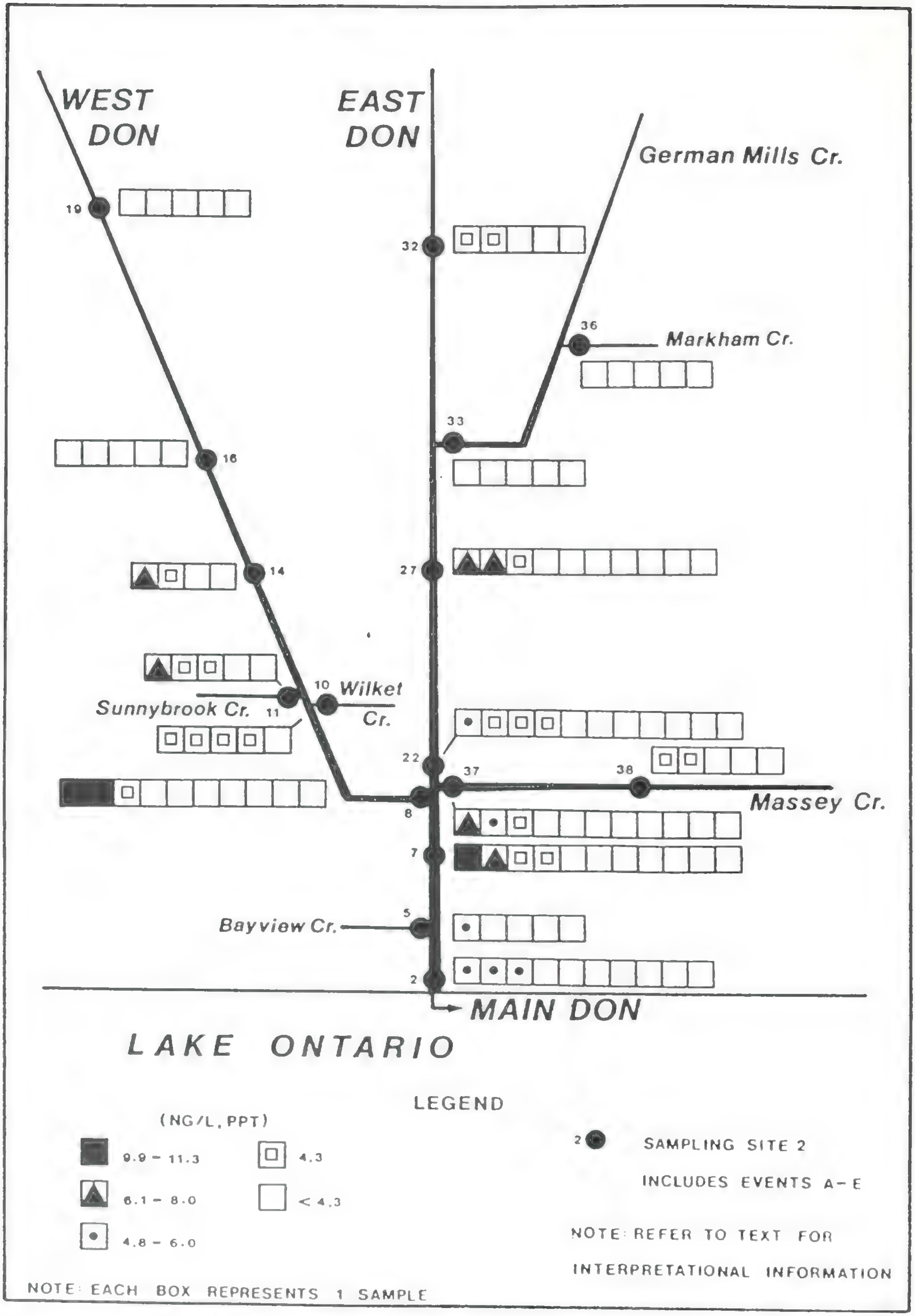

FIGURE 2.15a SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

CHLORDANE ALPHA (α)

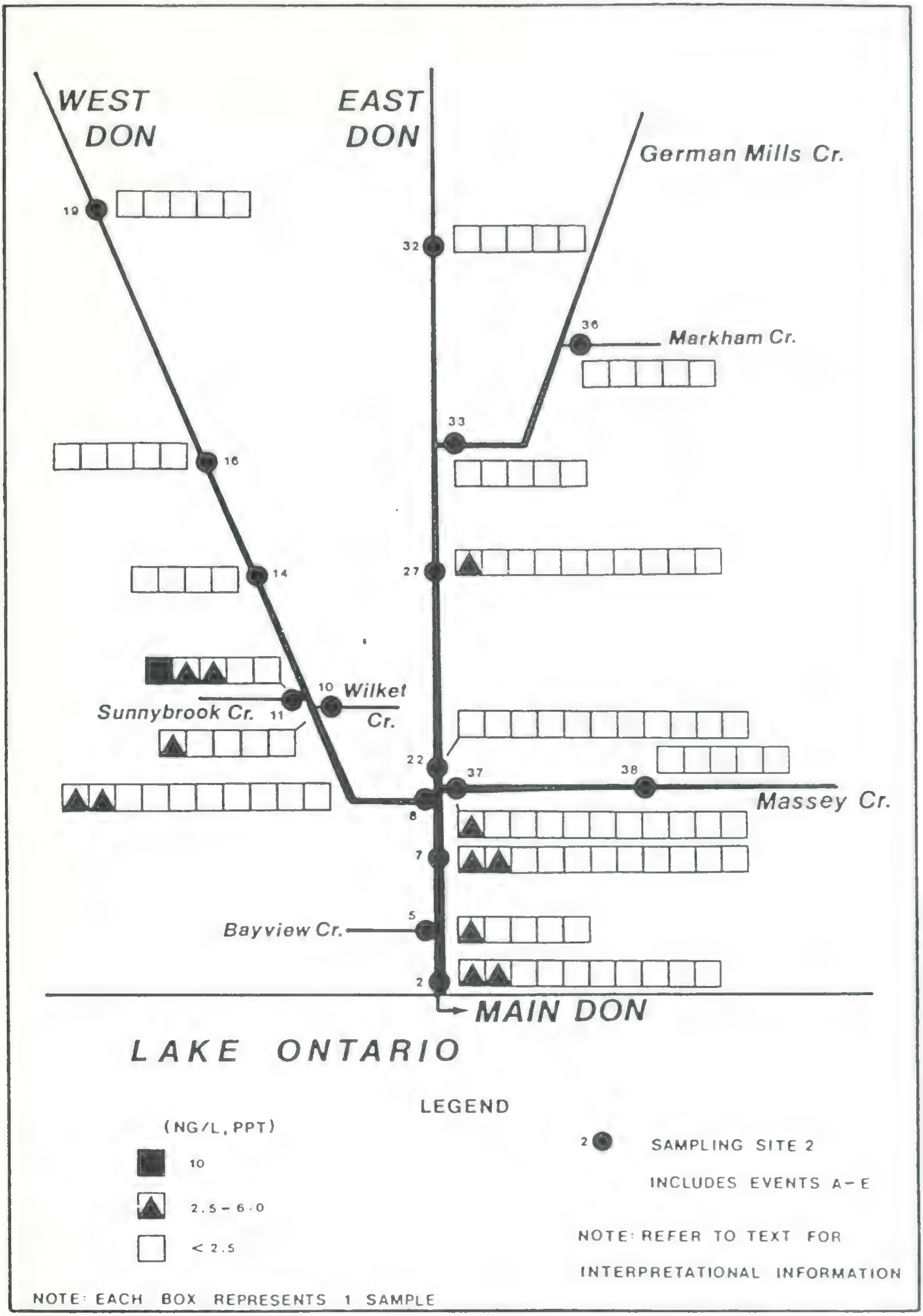

FIGURE 2.15b SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

DDT and BHC Isomers

The exceedance of these isomers is given in Figure 2.16 to 2.17. These compounds were widely used for insecticides until greatly restricted or banned. They were particularly effective for pests in low concentrations and were used for agriculture and horticulture purposes. Their long persistence (ten to twenty-five years) led to their being banned for agricultural use, but they may still be found in soils.

Lindane, the gamma isomers of BHC, is used for veterinary purposes. The highest levels of lindane in the Don River watershed are observed in the Massey Creek. Zubovits (1987) suggests that the veterinary sources could be the main source of this contamination because approximately 20% of all veterinary offices in Toronto are located in the Massey Creek watershed.

Methoxychlor and Endosulfan

Methoxychlor has a strong residual action against many insects and a low toxicity to humans and warm-blooded animals. It is used as a replacement for DDT and lindane for the control of pests on shade trees in parks and home gardens or where application poses dangers to warm-blooded animals. It is present in 59 registered pesticides which have varying degrees of toxicity (schedule 2, LD50 oral of 50-100 mg/kg to Schedule 5: LD50 oral of LT 5,000 mg/kg). Endosulfan is popular for control of a variety of pests including aphids, beetles, caterpillars, mites, borers, slugs, etc. It is present in 12 pesticides (Schedule 1 and 2 groups) applied to vegetables and ornamentals.

Levels of these compounds are given in Figure 2.18 and 2.19. The significant concentrations of these compounds in the southeast areas of Toronto suggested to Zubovits (1987) that they result from relatively high application rates used by landscaping companies which take care of gardens in these areas.

Phenoxy Herbicides

In addition to phenolic compounds derived from wood preservative residues and other industrial sources, phenolic substances are also normal breakdown products of phenoxy herbicides such as 2,4-D. No exceedances of PWQO's were detected for such herbicides, but Zubovits notes that they have been detected in various golf courses and city parks

PP^{I}-DDD

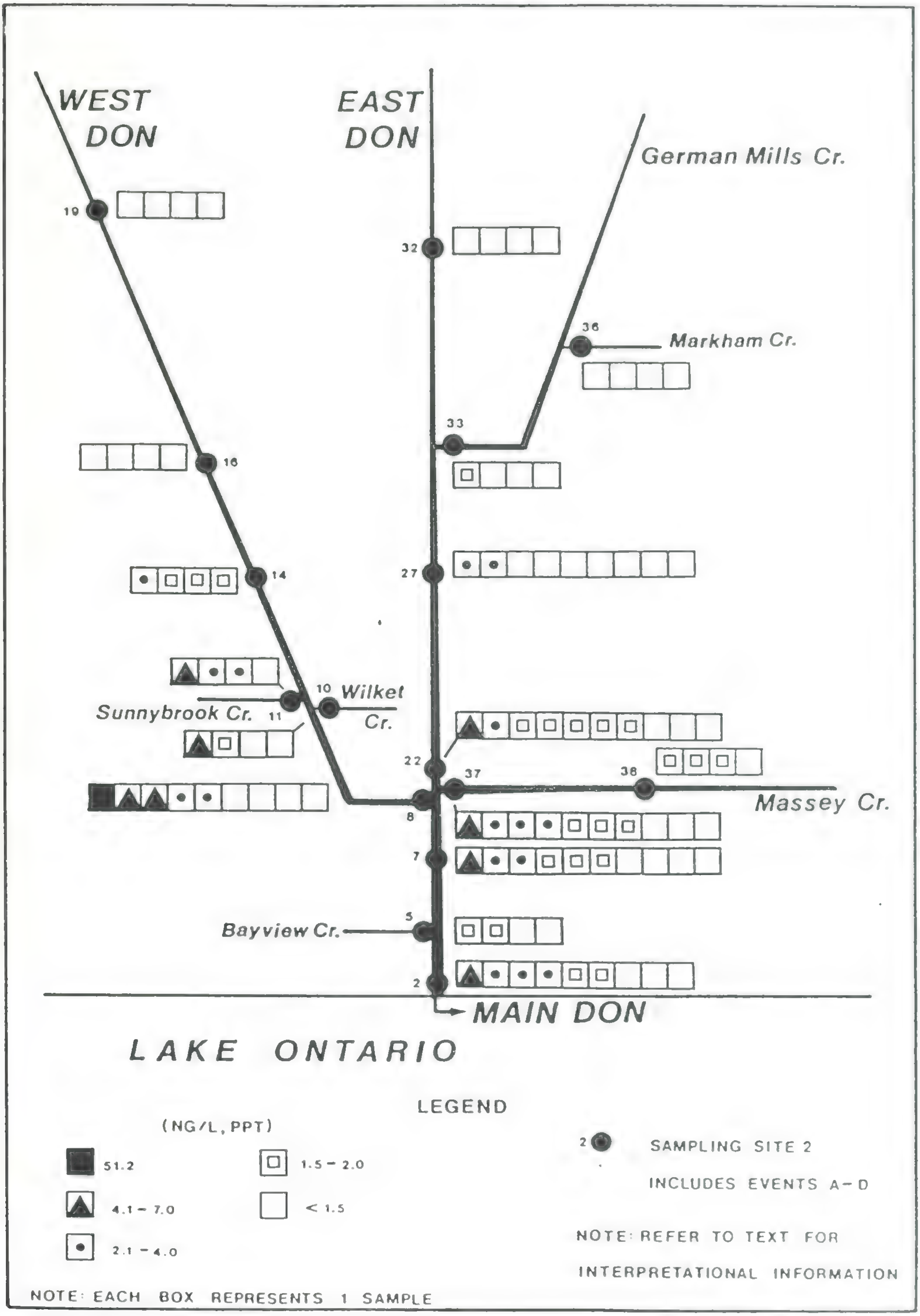

FIGURE 2.16a SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

PP'–DDE

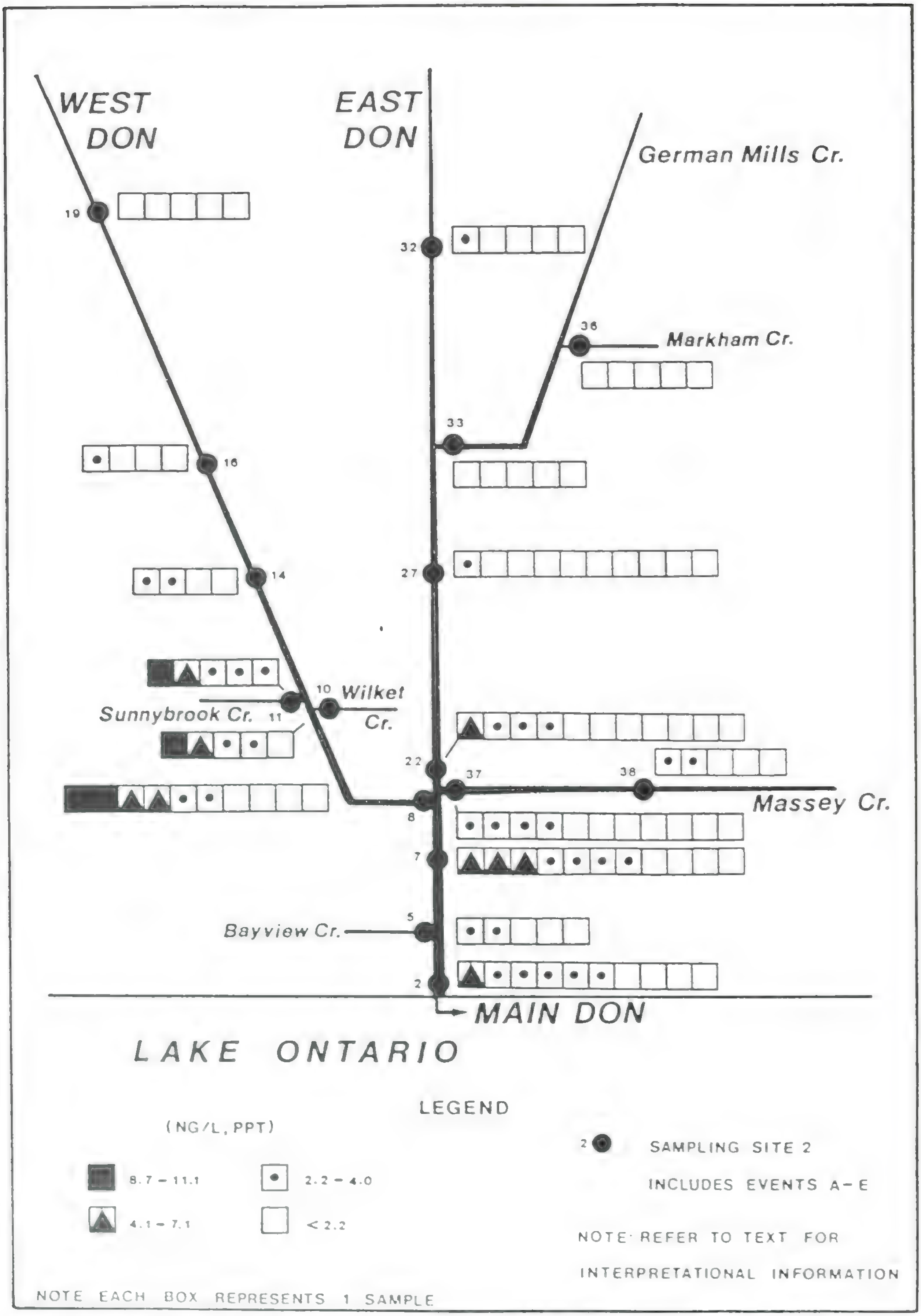

FIGURE 2.16b SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

HEXACHLOROCYCLOHEXANE ALPHA (BHC α)

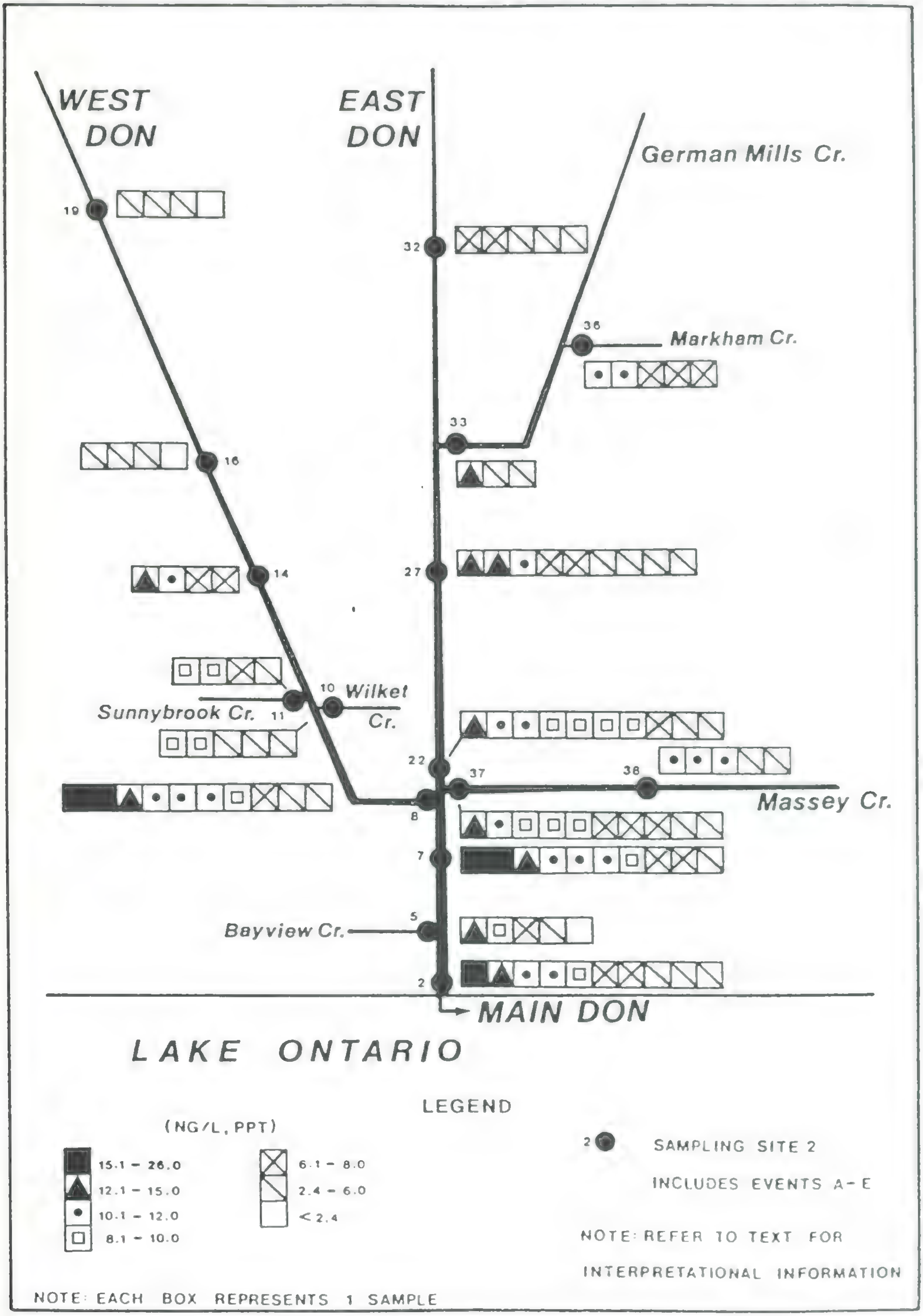

FIGURE 2.17a SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

HEXACHLOROCYCLOHEXANE BETA (BHC β)

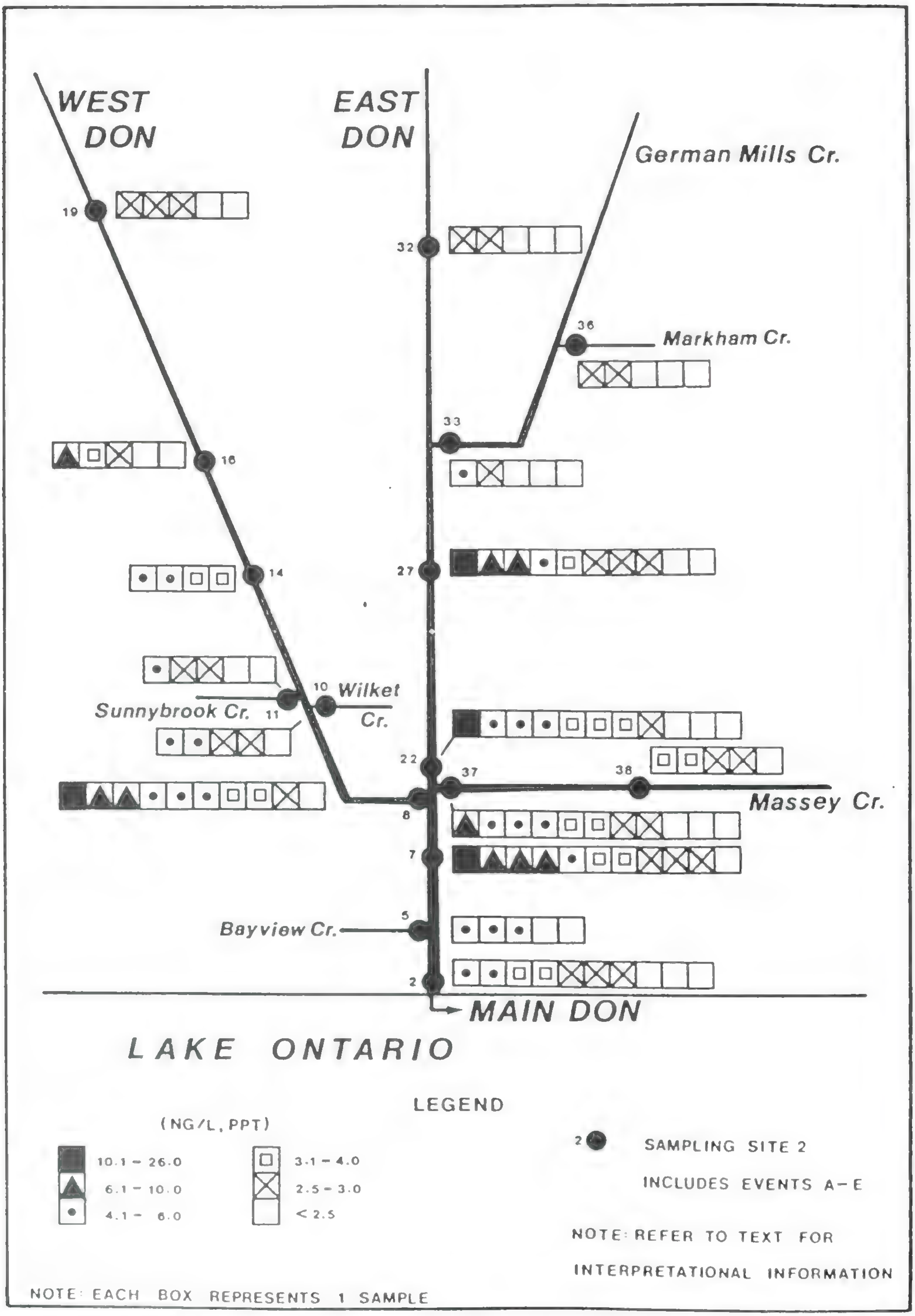

FIGURE 2.17b SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

HEXACHLOROCYCLOHEXANE GAMMA (BHC γ)

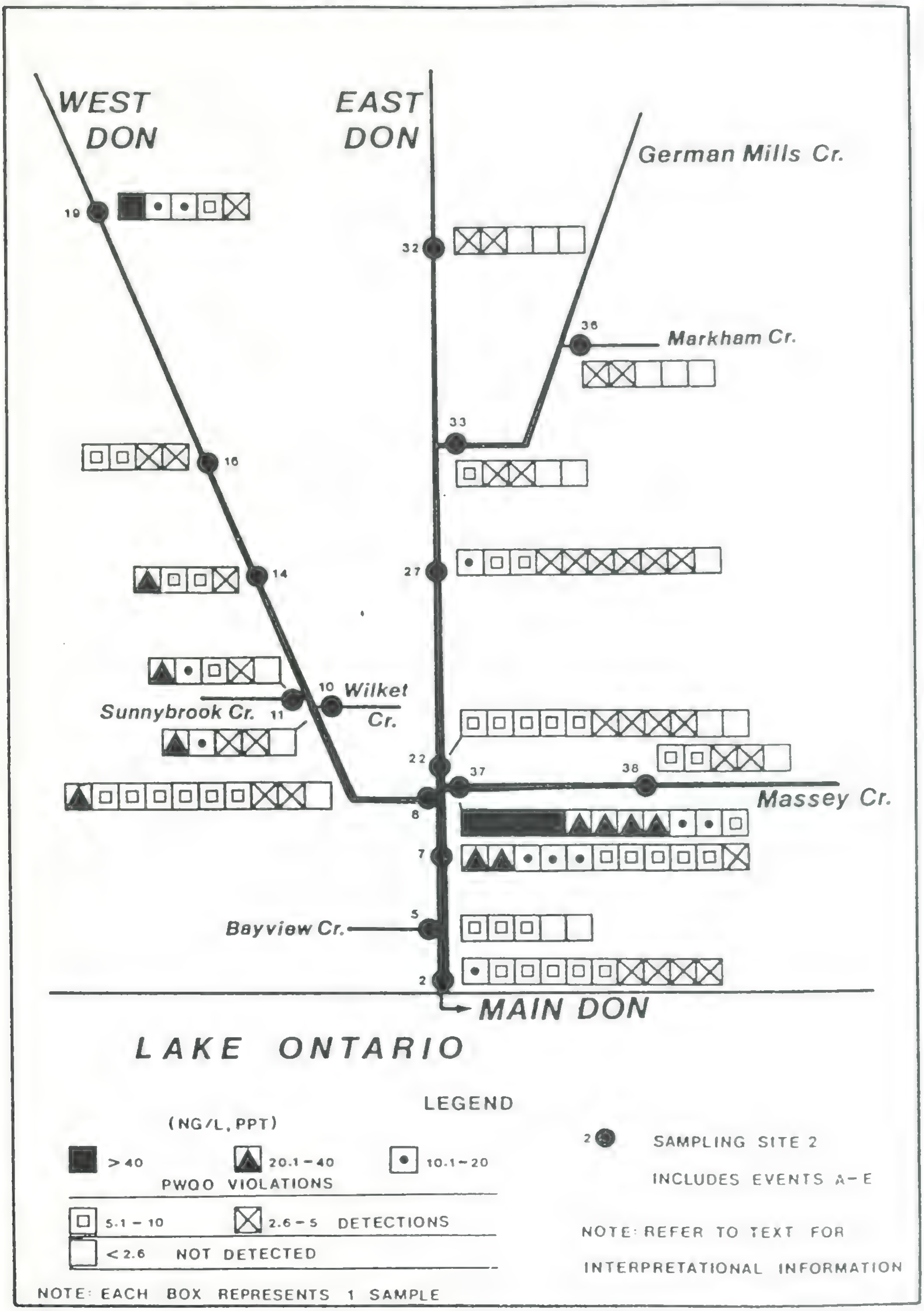

FIGURE 2.17c SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

METHOXYCHLOR

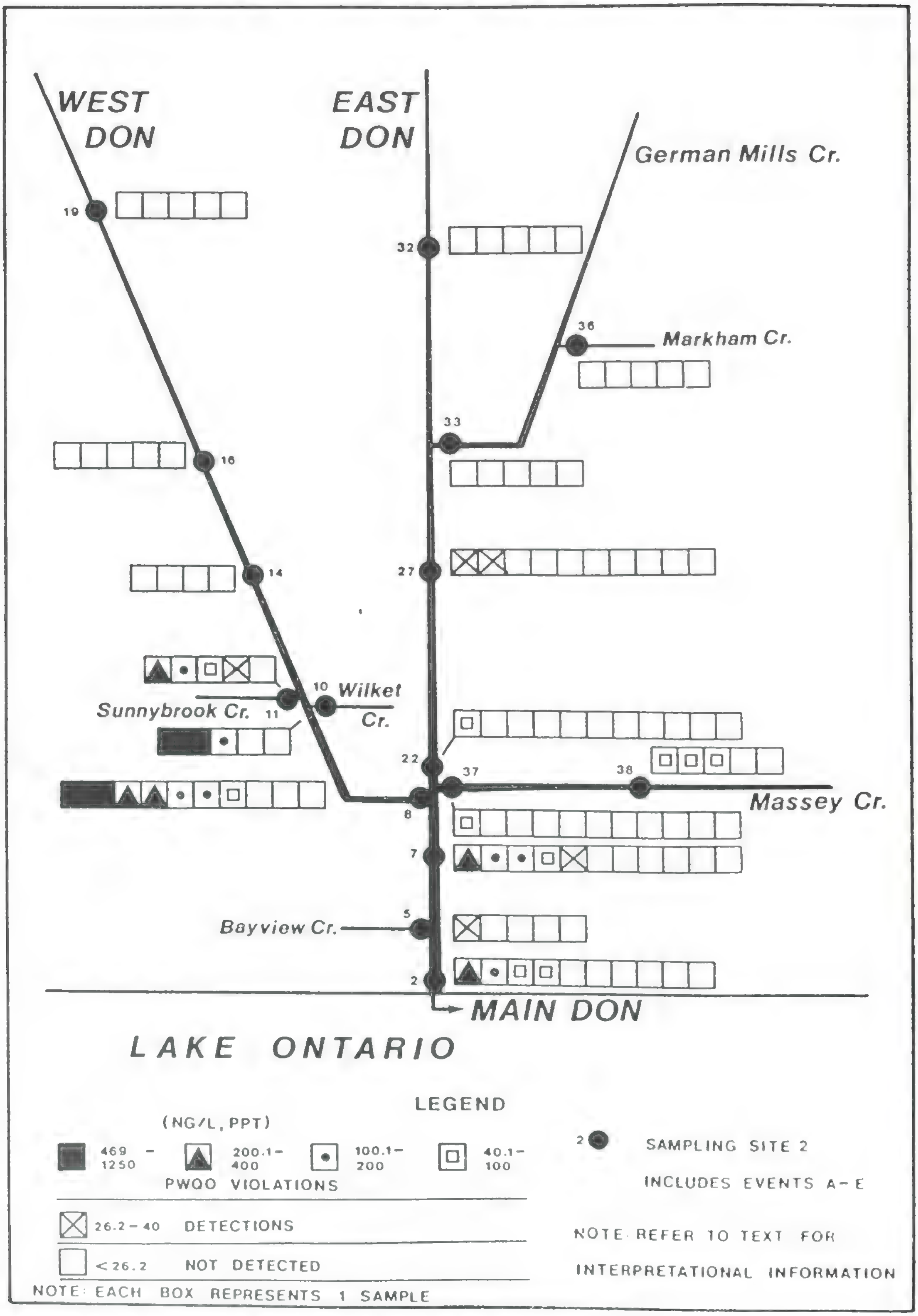

FIGURE 2.18 SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

ENDOSULFAN

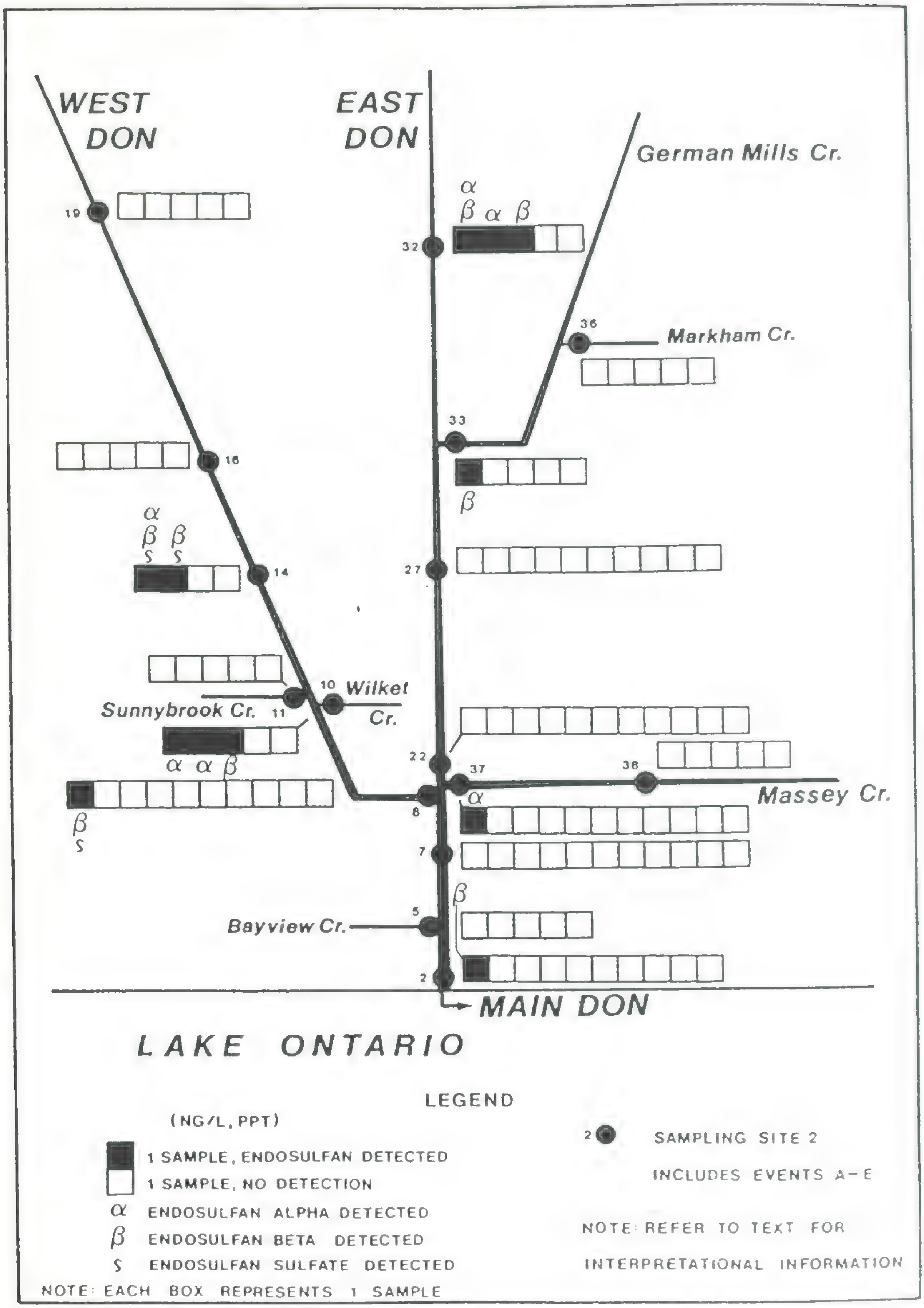

FIGURE 2.19 SPRING SNOWMELT RUNOFF STUDIES DATA BASE, DON RIVER AND TRIBUTARIES, 1984

where an intensive level of groundskeeping is practised. This suggests that a continued "detective" work level of monitoring is approriate for such compounds.

Colour and Other Organic Compounds (Humics/Fulvic Substances)

Colour in natural waters results from the selective absorption of the various wavelengths of light by dissolved substances in water or by scattering of the light by suspended particulates. The former is referred to as true colour while the combined effect is apparent colour (APHA, 1985).

True colour in natural waters commonly is caused by the occurrence of complex organic compounds arising from bacterial and/or chemical decomposition of naturally occurring organic matter. In most natural systems, colour is a by-product of biological activity. Chief sources are lignin and humic materials leached from soils or from decaying plankton or aquatic plants. Similar lignin derivatives are removed from wood during pulping operations producing paper fibre. This colour is a normal constituent of pulp mill effluents.

Because natural water has a large range of colour, agencies responsible for regulation of water quality (e.g., Ontario Ministry of the Environment, Environment Canada, U.S. Environmental Protection Agency) have not established numerical guidelines or standards to define the requirements for the protection of the aquatic environment. The only potential impact of colour has been associated with the reduction of light for photosynthetic activity over a long-termperiod. (U.S. National Academy of Sciences, 1972). This potential impact was also recognized by the Ontario Water Resources Commission (1970) in their guidelines but has been deleted in the current MOE "Blue Book" of Water Management Objectives (1984). At present there are no standards for receiving water colour in Ontario.

The presence of colour is not necessarily a problem. For example many of Ontario's recreational lakes are relatively coloured by natural humics or compounds. Such colour is an apparent yellowish-brown colour, but has not impaired their use for aesthetic enjoyment. In other streams impacted by acid mine drainage, the streams are quite clear but are devoid of aquatic life due to the acidity.

In the Don River, the impact of surface oil slicks and dissolved substances can cause a grey appearance. The compounds which cause such colour has not been defined. Colour measurements in the Don have not been analysed. Accordingly, while the parameter "colour" is a key to assessing aesthetics, it cannot be used in this study without further analysis.

There is often a strong correlation between colour, light absorbance at 254 mm and humic substances or DOC. Such correlation and measurements of DOC could be used as a surrogate for colours. Available data do not permit the approach.

Priorities for Sampling and Abatement of Pesticides and Herbicides

Based upon the above literature, Sollett (1987) suggested a set of priorities for pesticides, herbicides and industrial organics for sampling and abatement in specific areas.

Methoxychlor: Wilket Creek, Sunnybrook Creek, Lower West Branch and perhaps Massey Creek.

Lindane: Massey Creek.

Reactive Phenolics: lower West Branch.

pp'-DDE: Wilket Creek, Sunnybrooke Creek and lower west branch.

Based upon trends, fish concentration and the analysis of Zubovits, the following priorities result:

1. PCB's are declining in the river since initiation of sampling, but the tissue of fish caught in the Don exceeded Ministry guidelines. This suggested the need to include PCB's in this study. Except for transformer leakage for which we have not been able to establish loadings soil containment levels, most of the PCB flux to the watershed will be atmospheric deposition and volatilization. This makes the modelling of PCB's difficult within the approach of this study. Furthermore, it is not clear the degree to which fish contamination results from Don River and how much results from lake influence.

The "loading-river concentration" approval of this study is inadequate for PCB's. A different approach is suggested as a special study for Phase II.

2. The trend of organochlorine pesticides was not clearly established, setting no priority.

3. The trend of reactive phenolics has been decreasing since the 1960's. PCP's had their most significance exceedances of PWQO's prior to 1983, suggesting that they are less of a priority.

4. HCB is significantly lower over the period 1979-1986.

5. Methoxychlor was detected since 1985 and has been used as a replacement for DDT, lindane and other similar pesticides.